ROLE OF MDCT IN PATIENTS OF ACUTE MESENTERIC ISCHEMIA AND CORRELATION WITH CLINICO-SURGICAL OUTCOME

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To

My Family and

Respected

Teachers

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ABBREVIATIONS

ALPHA–GST	Serum Alpha-Glutathione S-Transferase
AMI	Acute Mesenteric Ischemia
CABA	Cobalt-Albumin Binding Assay
I-FABP	Intestinal Fatty Acid Binding Protein
IMA	Inferior Mesenteric Artery
IMV	Inferior Mesenteric Vein
MAE	Mesenteric Arterial Embolism
MAT	Mesenteric Arterial Thrombosis
MDCT	Multidetector Computed Tomography
MIP	Maximum Intensity Projection
MVT	Mesenteric Venous Thrombosis
NOMI	Non-occlusive Mesenteric Ischemia
SMA	Superior Mesenteric Artery
SMV	Superior Mesenteric Vein
USG / US	Ultrasound

ABSTRACT

Introduction: Acute mesenteric ischemia is an abdominal emergency occurring in nearly 1% of patients presenting with acute abdomen. Early diagnosis is very important for the improved survival of the patient. Acute mesenteric ischemia frequently presents with non-specific features such as vomiting, loose stools and abdominal distension. The classical triad of fever, hematochezia and abdominal pain is seen in only 30% of the patients so it is difficult to diagnose clinically. MDCT is gold standard and first line test to diagnose intestinal ischemia.

Aims and objectives of study: To assess the efficacy of Multi-Detector Computed Tomography (MDCT) in the diagnosis of acute mesenteric ischemia and to correlate it with surgical and/or clinical outcome.

Materials and methods: In this prospective study, MDCT was performed on 40 patients (23 M; 17 F, age range: 28-93 years). Axial and reconstructed images of each patient were evaluated for evidence of bowel wall thickening, bowel wall attenuation, abnormal wall enhancement, bowel dilatation, mesenteric stranding, ascites, solid organ infarcts, pneumatosis intestinalis or porto-mesenteric gas, and mesenteric arterial or venous thrombosis. MDCT findings were correlated with the surgical findings and clinical outcome.

Results: 27 patients underwent surgery and 13 patients were managed conservatively. Acute mesenteric ischemia was correctly diagnosed in 26 patients out of 27 on MDCT (96.39% accuracy). Three patients expired after surgery and three patients expired after conservative management, remaining 34 patients were stable on follow up. Mesenteric arterial thrombosis was seen in 20 patients (50%) while 13 patients (32.5%) had porto-mesenteric venous thrombosis and 7 (17.5%) patient had non-occlusive mesenteric ischemia. Reconstructed images using minimum intensity projection, volume rendering and multi-planar volume reconstruction were found helpful in the detection of vascular abnormalities and improving the diagnostic efficacy in the evaluation of bowel and mesenteric abnormalities.

Conclusion: MDCT is an effective non-invasive modality for the diagnosis of acute mesenteric ischemia.

Keywords: Acute mesenteric ischemia, Computed tomography, Arterial thrombosis

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INTRODUCTION

Acute mesenteric ischemia is caused by a reduction in blood flow for intestinal circulation of sufficient magnitude to compromise the viability of affected portion [1]. It is a rare and often fatal life-threatening condition, accounting for approximately 1 in 1000 hospital admissions. It has a reported high mortality rate of 50–90% [2-4] so requires early diagnosis and treatment. In the early 1990s, the overall mortality in acute mesenteric ischemia was over 80%, and survival reached 50% only under the most favorable circumstances when aggressive treatment with bowel resection was considered feasible [5]. High mortality rate has gradually improved but has not changed remarkably during the past decade, despite progress in diagnostic and treatment options [6], largely due to the difficulty of early detection and subsequent delay in appropriate management.

Most of the patients who come to the emergency department present with sudden onset of intense abdominal pain. It can be due to variety of diagnosis. After the patients come to the emergency department, they are subjected to medical and physical examinations and further with clinical interpretation and lab investigations, the clinician further favours for radiological examinations in order to arrive at an appropriate final diagnosis.

Severe abdominal pain out of proportion to physical examination findings should be assumed to be acute mesenteric ischemia until disproven.

The key to early diagnosis is a high level of clinical suspicion [7]. The clinical scenario of a patient complaining of excruciating abdominal pain with an unrevealing abdominal exam is classic for early acute mesenteric ischemia. If the physical exam demonstrates signs of peritonitis, there is likely irreversible intestinal ischemia with bowel necrosis. In a study of acute mesenteric ischemia, 95% of patients presented with abdominal pain, 44% with nausea, 35% with vomiting, 35% with diarrhoea, and 16%

with blood per rectum [8]. Approximately one-third of patients presented with the triad of abdominal pain, fever and haemoccult positive stools. Other patients, particularly those with delayed diagnosis, may present in extreme with septic shock. Clinical signs of peritonitis may be subtle. Accordingly, one must have a high index of suspicion, because such findings almost always are predictive of intestinal infarction.

Clinical scenario differentiates acute mesenteric ischemia as mesenteric arterial emboli, mesenteric arterial thrombosis, non-occlusive mesenteric ischemia or mesenteric venous thrombosis.

A careful history is important because distinct clinical scenarios are associated with the pathophysiological form of acute mesenteric ischemia. Patients with mesenteric arterial thrombosis often have a history of chronic postprandial abdominal pain, progressive weight loss, and previous revascularization procedures for mesenteric arterial occlusion. Patients with non-occlusive mesenteric ischemia have pain that is generally more diffuse and episodic associated with poor cardiac performance. Patients with mesenteric venous thrombosis present with a mixture of nausea, vomiting, diarrhoea, and abdominal cramping [9]. Gastrointestinal bleeding occurs in approximately 10%. Nearly 50% of patients presenting with embolic acute mesenteric ischemia have atrial fibrillation and approximately one-third of patients have a prior history of arterial embolus.

ROLE OF CONVENTIONAL PLAIN X-RAY FILMS

It has limited diagnostic value in evaluating AMI, although signs of intestinal perforation may be seen.

A radiograph is usually the initial test ordered in patients with acute abdominal pain but has a limited role in the diagnosis of mesenteric ischemia, especially in the early setting. A negative radiograph does not exclude mesenteric ischemia. Plain radiography only becomes positive when bowel infarction has developed and intestinal perforation manifests as free intraperitoneal air.

LABORATORY STUDIES

There are no lab studies that are sufficiently accurate to identify the presence or absence of ischemic or necrotic bowel, although elevated L-lactate and D-dimer may assist.

More than 90% of patients will have an abnormally elevated leukocyte count. The second most commonly encountered abnormal finding is metabolic acidosis with elevated lactate level [10].

Patients may present with lactic acidosis due to dehydration and decreased oral intake. Thus, differentiation of early ischemia versus irreversible bowel injury based upon the lactate level alone is not reliable unless accompanied by other clinical evidence.

Elevated serum lactate levels >2 mmol/l have been associated with irreversible intestinal ischemia in established diagnosis of AMI [11]. It should be emphasized that the presence of lactic acidosis in combination with abdominal pain when the patient may not otherwise appear clinically ill should lead to consideration for early CT angiography. Based on the current literature, no accurate biomarkers have been identified to date [12, 13].

D-dimer has been reported to be an independent risk factor of intestinal ischemia, reflecting ongoing clot formation and endogenous degradation via fibrinolysis. D-dimer >0.9 mg/L has a specificity, sensitivity, and accuracy of 82, 60, and 79%, respectively. Thus, D-dimer may well be useful in the early assessment. Elevated amylase has been reported in roughly a half of patients with AMI. Other biomarkers reported to assist in the diagnosis of AMI include intestinal fatty acid binding protein (I-FABP), serum alpha-glutathione S-transferase (alpha–GST), and cobalt-albumin binding assay (CABA). These biomarkers may offer improved diagnostic accuracy of acute mesenteric ischemia; however, further research is required to specify its accuracy and values.

ROLE OF ULTRASOUND

The efficacy of ultrasound (USG) in diagnosis of acute mesenteric ischemia has been evaluated in many studies. USG can demonstrate proximal mesenteric vessel thrombosis via doppler mode and can be used in detecting proximal superior mesenteric and celiac artery stenosis with high sensitivity and specificity of approximately 85% to 90% [14, 15]. US may also reveal focal superior mesenteric or portal venous thrombosis in cases of venous occlusive ischemia [16]. Unfortunately, the presence of overlying bowel gas, obesity, and vascular calcifications are challenges for an adequate sonographic evaluation. In addition, duplex US has a limited role in detecting distal arterial emboli or in diagnosing non-occlusive mesenteric ischemia. Moreover, the length of the examination and the possible pain associated with the applied pressure to the abdomen during imaging may be limiting factors in initial evaluation of patients with suspected acute mesenteric ischemia [17, 18].

In order to decrease the mortality rate and morbidity rate, an efficient and correct diagnosis should be given for these patients. It may be challenging because the clinical examination is tough, and investigations, like plain radiograph of the abdomen and USG examinations are usually inconclusive. In such cases, multi-detector computer tomography (MDCT) is a widely accepted primary investigation of choice in patients coming with intense abdominal pain [19-21]. It is the most rapid, specific, time efficient, objective and informative imaging technique. With the advanced technology of MDCT, multiple images can be acquired in a single tube rotation. The whole abdomen and pelvis can be scanned within a single breath hold at a thickness of 1mm in the 3D plane. These data sets result in voxels that are both submillimeter in dimension and isotropic, suggesting that reformations in any desired plane will have a spatial resolution similar to that of the axial plane**.** MDCT provides a global judgment of the gastrointestinal tract, mesenteries, solid organs, peritoneum and retroperitoneal areas. It also gives us clear data for

another possible diagnosis, if the working clinical diagnosis is incorrect and has a significant outcome in the treatment of patients with intense abdominal pain. With the introduction of multi planner reconstruction in the workstations, MDCT has led to a great improvement in the management of these patients.

Multidetector CT should be the first-line imaging modality when AMI is suspected. It is the most sensitive and specific diagnostic tool with as high as 96---100% sensitivity and 89---98% specificity in the diagnosis of AMI. It also allows other causes of acute abdominal pain to be excluded and has essentially replaced catheter angiography as the diagnostic tool for mesenteric ischemia. MDCT technology has dramatically improved the early diagnosis by allowing rapid volumetric data acquisition to provide increased longitudinal spatial resolution over a large anatomic volume.

- From the volume data, retrospective thin or thick sections; sagittal, coronal, or curved multiplanar reformatted images can be made.
- The rapid scanning capability of this technique coupled with IV bolus contrast injection substantially optimizes scan timing to allow both the arterial and venous phases to be imaged.
- It is helpful in identifying the site, level, and cause of bowel ischemia by showing abnormalities in the bowel wall, mesentery, and mesenteric vessels. In addition, other pathological conditions can also be detected in patients suspected of mesenteric ischemia.
- With these developments, the ability of CT for diagnosing mesenteric ischemia has recently been reported to have a sensitivity of approximately 90%. It can also provide alternative diagnoses for patients in whom mesenteric ischemia is suspected.

Twenty-five percent of the cardiac output goes to the splanchnic circulation at rest increasing to 35 % in the postprandial state. Seventy percent of mesenteric blood flows to the mucosa and submucosa and microscopic changes of ischemia can be detected within minutes.

Although the intestine can auto-regulate oxygen availability via enhanced oxygen extraction and perfusion due to vasodilation. Experimentally it had been shown that mesenteric ischemia does not occur until patient's mean arterial blood pressure is <45 mmHg [22]. Consequently, the small intestine is able to compensate for a 75 % reduction in blood flow for up to 12 hours [23]. Without significant injury, irreversible bowel damage occurs within 6 hours of complete vascular occlusion.

Acute mesenteric ischemia can be caused by various conditions such as arterial occlusion, venous occlusion and hypo-perfusion associated with non-occlusive vascular disease, and the CT findings vary widely depending on the cause and underlying pathophysiology.

CT findings of acute mesenteric ischemia should be characterized on the basis of the cause. In addition, the severity of bowel ischemia (i.e., superficial mucosal or transmural bowel wall necrosis), the location (i.e., small or large bowel), and the presence and degree of haemorrhage or subsequent super-infections may affect the CT appearance.

Various causes of AMI include mesenteric arterial embolism (MAE), mesenteric arterial thrombosis (MAT), mesenteric venous thrombosis (MVT), and non-occlusive mesenteric ischemia (NOMI).

Arterial causes of AMI are more common than venous causes. Strangulation of the intestine is a common and important cause of intestinal ischemia. However, it is usually considered to be secondary AMI rather than primary AMI because the pathophysiologic mechanisms of the two conditions are different. Bowel ischemia begins with reversible mucosal ischemia, which develops into irreversible ischemia over time and if untreated causes bowel necrosis, perforation, peritonitis, and possibly death.

Septic shock and multi-organ failure caused by bacterial translocation from disruption of the mucosal barrier can occur.

To improve the patient prognosis, early diagnosis, prompt and appropriate management are mandatory. Because neither the symptoms nor the

results of laboratory tests are specific, imaging studies play an important role in the diagnosis of mesenteric ischemia.

Management of AMI includes restoration of blood flow with surgical approach and resection of the necrotic bowel.

EMBRYOLOGY AND ANATOMY OF GUT

Primitive gut tube develops during week 3-4 by incorporating the yolk sac during cranio-caudal and lateral folding of the embryo. The tube is divided into 3 distinct sections: foregut, mid-gut and hindgut. Foregut gives rise to the oesophagus, stomach, liver, gallbladder, bile ducts, pancreas and proximal duodenum. The mid-gut develops into the distal duodenum, jejunum, ileum, cecum, appendix, ascending colon, and proximal 2/3 of transverse colon. The hindgut becomes the distal 1/3 of the transverse colon, descending colon, sigmoid colon and the upper anal canal.

The foregut gives rise to the oesophagus, stomach, liver, gallbladder, pancreas and the caudal portion of the duodenum. The stomach develops from a fusiform dilatation in the foregut during week 4. A 90 degree clockwise rotation creates the lesser peritoneal sac

The distal duodenum, jejunum, ileum, cecum, appendix, ascending colon, and proximal 2/3 of transverse colon develop from the mid-gut, between 6 to 10 weeks. The mid-gut loop herniates through the primitive umbilical ring during umbilical herniation at week 6. By ten weeks of development, the abdomen has enlarged so that the entire length of the mid-gut can be accommodated. Following a 270 degree counter-clockwise rotation around the superior mesenteric artery, the bowel returns to the abdominal cavity. The large intestine returns following the small intestine and does an additional 180 degree counter-clockwise rotation. Colonic fixation occurs after the return to the abdomen. Cecum and appendix begin as a diverticulum around the 6^{th} week. Unequal caecal growth leaves appendix medial to the cecum.

The distal 1/3 of the transverse colon, descending colon, sigmoid colon develop from the cranial end of the hindgut. The upper anal canal also develops from the terminal end of the hindgut with the uro-rectal septum dividing the upper anal canal and the urogenital sinus during the 6th week. By the 7th week, the uro-rectal septum fuses with the cloacal membrane, giving rise to the anal membrane and the urogenital membrane. The anal membrane ruptures during the 8th week allowing communication between the anal canal and the amniotic fluid. The superior 2/3 of the anal canal originates from hindgut and the inferior 1/3 is derived from proctodeum. The pectinate line is the junction of proctodeum, ectoderm and hindgut endoderm.

MESENTERIC CIRCULATION AND COLLATERAL NETWORK

The SMA arises from the abdominal aorta, usually at the level of the L1 vertebral body, and supplies blood to the jejunum, ileum, right colon, and, usually, the transverse colon. It also supplies blood to the duodenum via the pancreatico-duodenal arcade. Typically, the SMA arises less than1.5 cm below the celiac origin and is just superior to the origin of the renal arteries. The left renal vein is located posterior to the proximal portion of the SMA and anterior to the aorta, unless there is a normal variant such as a retro-aortic or circum-aortic renal vein. The SMA lies to the left of the SMV as it crosses over the third portion of the duodenum. When the SMA enters the mesentery, it usually lies posterior to the mesenteric vein, although this relationship is variable.

The jejunal arteries (usually 4–6 arteries) arise from the left side of the SMA. These arteries are quite small and are therefore very difficult to visualize and identify on axial images.

The ileocolic artery, which arises from the right side of the SMA, marks the transition from jejunal to ileal arteries. There are usually between 8 and 12 ileal arteries [24, 25]. The branching pattern of the last jejunal artery, ileo-

colic artery and ileal arteries varies, sometimes forming a loop or tripod. The ileo-colic artery has branches to the terminal ileum, cecum, and lower ascending colon.

The right colic artery can arise from the SMA to aid the ileo-colic and middle colic arteries in supplying blood to the ascending colon. However, it is absent in up to 80% of individuals.

The middle colic artery usually arises from the right side of the SMA just before it enters the mesentery. It descends into the right lower quadrant, where it anastomoses with the ileo-colic artery.

Other branches that may arise from the SMA include an artery for the right angle of the colon and one for the transverse colon. There are also anastomotic connections between the artery to the transverse colon and the left colic artery, which arises from the IMA. Many variations exist.

The inferior pancreatico-duodenal artery is the pivotal point of embryologic gut rotation. It can arise from either the right or left side of the SMA and may arise as one vessel or two (anterior and posterior). This vessel courses behind the SMV and superiorly to anastomose with the superior pancreatico-duodenal artery, which arises from the gastro-duodenal artery.

The marginal arteries of Dwight and Drummond supply the vasa recta to the small intestine and colon and provide a continuous channel of potential collateral blood supply to the entire gut [26]. The marginal artery is defined as the artery closest to and parallel with the wall of the intestine, supplying the vasa recta. The vasa recta are fine branches that arise from the marginal artery and supply the bowel wall. The middle colic artery is often the marginal artery for the major portion of its distribution.

The arc of riolan is an inconstant artery that courses parallel to a portion of the middle colic artery.

Aberrant branches from the SMA are relatively common. They include the common hepatic artery, right hepatic artery, splenic artery, celiac trunk, cystic artery, gastro-duodenal artery, right gastro-epiploic artery, and left gastric artery [27].

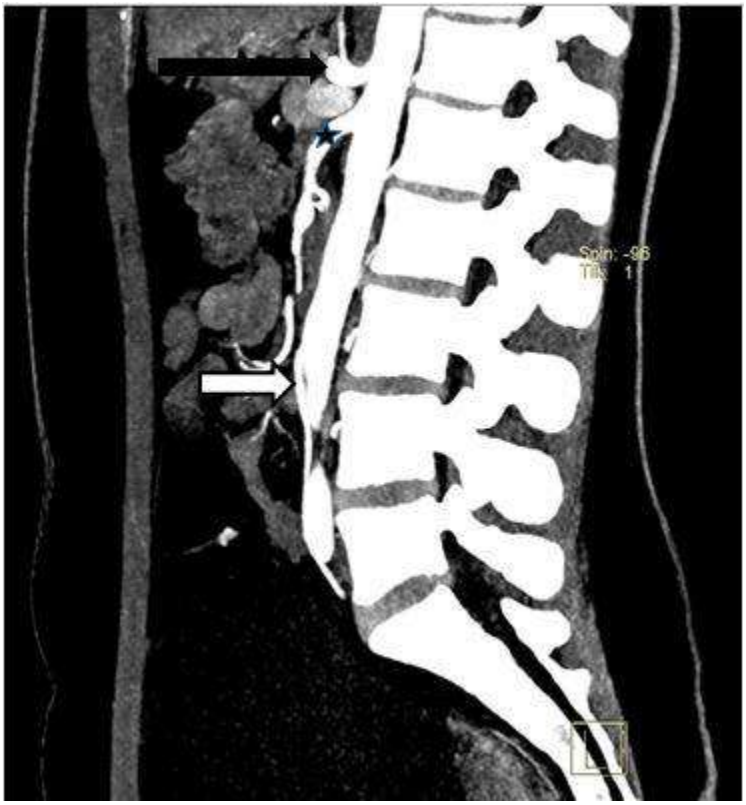

Figure 1: Illustration of origin of major mesenteric arteries arising from abdominal aorta
(long arrow represents celiac trunk, ★ represents SMA and short arrow represents IMA)

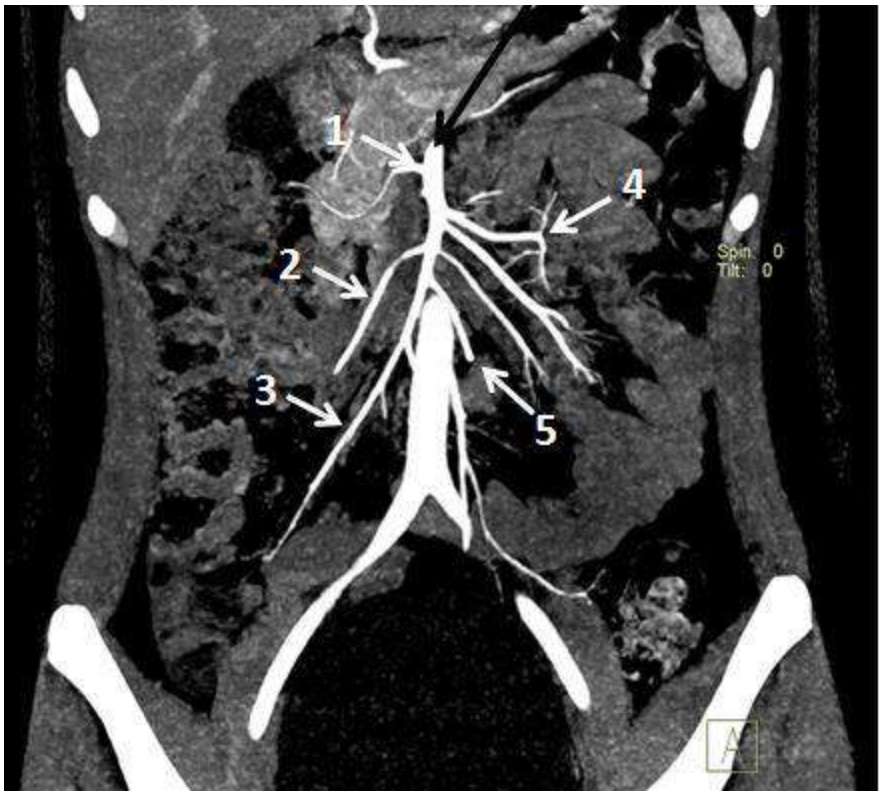

Figure 2: Coronal 3D multi– detector row CT scan demonstrates the normal anatomy and branching pattern of the SMA {long black arrow}. The jejunal branches {4} and ileal branches {5} are well visualized. The ileocolic branch {3} of the SMA arises from the right side of the vessel .The middle colic artery and right colic artery {1 and 2 respectively} is also identified.

INFERIOR MESENTERIC ARTERY

The IMA arises from the aorta approximately 7cm below the origin of the SMA, usually at the level of L3 vertebra. It is a relatively straight vessel with several branches, all of which arise from the left side [27, 28]. The left colic artery forms anastomosis with the artery to the transverse colon, which arises from the SMA. It is absent in 12% of individuals, in whom its function is performed by the colo-sigmoid artery.

The colo-sigmoid artery also arises from the left side of the IMA and supplies blood to the descending and sigmoid colon. There are usually two to four sigmoid branches that can arise from the IMA, colo-sigmoid artery, or left colic artery. The next branch of the IMA is the recto-sigmoid artery. Finally, after the origin of the recto-sigmoid artery, the IMA bifurcates into the superior rectal arteries. The colo-sigmoid artery can arise from the left colic artery or from the angle between the left colic artery and the IMA. The left colic artery can be absent or can arise from the SMA.

SUPERIOR MESENTERIC VEIN

The SMV is usually a single trunk of variable length (5–50 mm) that is formed by two large intestinal branches (right and left), which receive blood from several veins including the ileocolic, gastrocolic, right colic, and middle colic veins. In some patients, a single trunk may not be present. Instead, there may be large right and left mesenteric branches, both of which join the splenic vein to form the portal vein. The SMV lies to the right of the SMA as it crosses over the third portion of the duodenum. When the superior mesenteric vessels enter the mesentery, the SMV usually lies anterior to the SMA, although this relationship is variable.

INFERIOR MESENTERIC VEIN

The major tributaries of the IMV include the superior haemorrhoidal vein, sigmoid vein, and left colic vein. The haemorrhoidal vein and sigmoid vein usually join to form a common trunk before uniting with the left colic vein. The IMV can terminate into the splenic vein or at the spleno-portal angle or may drain into the SMV [29].

DIAGNOSTIC ROLE OF MULTIDETECTOR CT

Since neither the symptoms of mesenteric ischemia nor the results of laboratory tests are specific for the diagnosis, imaging plays an important

role in the diagnosis of mesenteric ischemia. Multidetector CT is the most accurate diagnostic tool for AMI and should be used as the first-line imaging modality when AMI is suspected. Findings at multidetector CT can help exclude other causes of acute abdominal pain.

CT images should be obtained from the dome of the liver to the level of the perineum to cover the entire course of the intestine. Acquisition of both non-contrast and contrast-enhanced CT images is necessary. Therefore, routine abdominal imaging should be performed with multidetector CT to obtain contrast-enhanced CT volume data in the arterial and venous phases, with dynamic injection of contrast material by a power injector after non-enhanced imaging is performed.

Between 100 and 150 mL of non ionic iodinated contrast material is administered at a rate of 2.5–4 mL per second, with scanning delay times of 30 seconds for the arterial phase and 60–70 seconds for the venous phase [30, 31]. From the volume data obtained, with a collimation of 0.5–2.5-mm sections and a detector pitch of 1.0–2.0 images with a 5-mm section thickness are usually constructed for image interpretation. However, thinner sections with a contiguous thickness of 1–2 mm should also be constructed for precise evaluation and for multi planar image reformations and CT angiography.

Sagittal images are helpful for assessing the origin of the mesenteric arteries from the aorta and its variations. Obtaining coronal images and performing CT angiography using maximum intensity projection (MIP) and volume rendering are valuable for assessment of vascular anatomy and sites of interruption of the arterial blood supply by emboli.

Use of oral contrast material is generally not appropriate in patients with AMI, as luminal contrast material obscures the assessment of bowel wall

enhancement. The increase in procedure wait time can also cause delays in diagnosis, as associated adynamic ileus often prevents the propagation of luminal contrast material.

CT FINDINGS IN ACUTE BOWEL ISCHEMIA

Acute mesenteric ischemia provides various morphologic and attenuation abnormalities on CT images in bowel wall, mesenteric vessels, and in mesentery. The lumen of the bowel may dilate when filled with air or fluid. These variations depend on pathogenesis of bowel ischemia as well as the acuteness, duration, site, and extent of the ischemic attack and the state of the collateral circulation.

Superimposed bowel wall infection and presence of perforation may also affect CT appearances of acute bowel ischemia. During interpretation, radiologists should assess the bowel wall, its thickness and attenuation; luminal dilatation; mesenteric vessels; mesentery; and other organs [30-32].

Bowel wall thickness— Normal bowel wall ranges from 3 to 5 mm thick depending on the degree of bowel distension [33]. Bowel wall thickening is not a specific but is most frequently observed CT finding in mesenteric ischemia and is caused by mural edema, haemorrhage, or super-infection of the ischemic bowel wall [34].

The degree of thickening is usually less than 1.5 cm, typically 8–9 mm [35], and is often observed in mesenteric venous occlusion, strangulation, ischemic colitis, and mesenteric arterial occlusion after reperfusion. In exclusively arterial occlusive mesenteric ischemia or infarction, the bowel wall becomes thinner rather than thicker because there is no arterial flow and neither mural edema nor haemorrhage occurs. Thinning of the bowel wall or “paper-thin wall” is caused by volume loss of tissue and vessels in the bowel wall and by loss of intestinal muscular tone .Bowel wall

thickening is not a consistent CT finding in mesenteric ischemia, and the degree of thickening does not correlate with severity.

Bowel wall attenuation—Bowel wall attenuation should always be assessed on both unenhanced and contrast-enhanced CT images to avoid misinterpretation of high density of the bowel wall as normal positive enhancement on contrast-enhanced CT in cases of intramural haemorrhage. On unenhanced CT images, low attenuation of the bowel wall indicates bowel wall edema, which typically occurs in mesenteric arterial occlusion after reperfusion, mesenteric venous occlusion, strangulation, and ischemic colitis. High attenuation of the wall is caused by intramural haemorrhage and hemorrhagic infarction [36].

On contrast-enhanced CT, a highly specific but not sensitive finding for acute mesenteric ischemia is absent or diminished contrast enhancement of the bowel wall [37]. A halo or target appearance is also indicative of mesenteric ischemia, representing hyperaemia and hyper-perfusion associated with surrounding mural edema, and can be seen in arterial occlusion after reperfusion, non-occlusive and veno-occlusive bowel ischemia, strangulation, and ischemic colitis [38]. Although it seems paradoxical, hyper-enhancement of the bowel wall caused by hyperaemia (mesenteric venous occlusion), hyper-perfusion (reperfusion after arterial occlusive or non-occlusive bowel ischemia), or prolonged enhancement due to reduction of arterial perfusion and venous outflow (strangulating bowel obstruction, non-occlusive bowel ischemia, shock bowel) may be observed in cases of mesenteric ischemia.

Pneumatosis intestinalis can be indicated when CT depicts air in the bowel wall.

In the setting of mesenteric ischemia, pneumatosis often indicates transmural infarction, particularly if it is associated with porto-mesenteric venous gas [39-41].

Dilatation of the Bowel Lumen

The bowel lumen is often dilated because of interruption of normal bowel peristalsis (adynamic ileus). Fluid distension of bowel loops occurs by increased intestinal secretions, typically in venoocclusive ischemia and strangulating bowel obstruction. In exclusive arterial occlusion, the bowel seldom contains a large amount of luminal fluid.

Mesenteric Vessels

In most cases, emboli or thrombi in the mesenteric arteries and veins are clearly shown on contrast-enhanced CT images; CT angiography may be helpful in seeing them. Engorgement of the mesenteric veins caused by congestion of venous outflow is typically seen in veno-occlusive bowel ischemia or strangulating bowel obstruction.

Mesentery

Mesenteric fat stranding and ascites appear with transudation of fluid in the mesentery or the peritoneal cavity caused by elevation of mesenteric venous pressure, which is commonly seen in strangulating bowel obstruction and veno-occlusive bowel ischemia. It is also frequently seen in ischemic colitis because of super-infection of ischemic colonic segments. Therefore, mesenteric fat stranding in these conditions can appear without bowel infarction and has limited value in estimating the severity of bowel ischemia.

On the other hand, in patients with arterial occlusive mesenteric ischemia, because CT finding of fat stranding is almost exclusively present with

transmural infarction, this finding can be helpful in estimating the severity of bowel ischemia.

BOWEL ISCHEMIA AND INFARCTION IN VARIOUS CONDITIONS

Bowel ischemia and infarction can be caused by various conditions such as mesenteric arterial occlusion, mesenteric venous occlusion, strangulating bowel obstruction, and hypo-perfusion associated with non-occlusive vascular disease.

Acute Mesenteric Arterial Occlusion

Acute mesenteric arterial occlusion is typically caused by a thrombo-embolism associated with cardiovascular problems followed by arterial thrombosis, which accounts for 60–75% (arterial embolism, 40–50%; arterial thrombosis, 20–30%) of all acute bowel ischemia cases [42-44].

Most emboli wedge at branching points around or distal to the middle colic artery, whereas thrombosis typically occurs at or near the origin of the mesenteric arteries.

Although the severity may vary, bowel ischemia is typically followed by infarction, perforation, and peritonitis unless reperfusion occurs.

On contrast-enhanced CT images, emboli and thrombi can be seen as defects in the superior mesenteric artery and its branches.

The thickness of the bowel wall of the involved segments is the same as or thinner than that of the healthy segments unless reperfusion occurs. The lumen of the bowel may be filled with fluid, gas, or both; however, the

bowel seldom contains a large amount of fluid. Contrast enhancement of the involved bowel is absent or diminished.

Pneumatosis can typically be observed in cases with transmural infarction with or without associated porto-mesenteric venous gas. In cases with reperfusion or rich collaterals, the involved bowel segments may thicken and show the halo or target pattern of contrast enhancement. Coexisting embolism of other organs may also be observed on contrast-enhanced CT, which supports the diagnosis of mesenteric ischemia.

The diagnosis of acute mesenteric arterial occlusion is usually made based on a combination of the CT findings described earlier.

The diagnostic performance of CT for primary mesenteric ischemia, including arterial and venous occlusive and non-occlusive mesenteric ischemia, has been reported as 64–96% in sensitivity and 92–100% in specificity. In the case of each CT finding, a lack of focal bowel wall enhancement and the presence of pneumatosis intestinalis are relatively sensitive and highly specific.

Findings of defects or occlusion of the mesenteric arteries or veins and gas in the mesenteric or portal veins or in the mesenteric arteries are less sensitive (12–15%) but are highly specific (94–100%).

Findings of bowel wall thickening and mesenteric stranding are relatively high in sensitivity (85–88%) but are less specific (61–72%).

Venous Occlusion

Thrombosis of the mesenteric vein can be primary or secondary to portal hypertension or infection or can be associated with various hyper-coagulopathy states [45]. Mesenteric venous obstruction does not typically

lead to severe bowel ischemia; however, thrombosis of the mesenteric vein, particularly at a distal level, may cause bowel infarction and accounts for 5–10% of acute bowel ischemia. Impairment of venous drainage causes elevation of the hydrostatic pressure, which leads to extra vascular leakage of plasma, RBCs, or both into the bowel wall, mesentery, and peritoneal cavity. The bowel loops are typically prominently dilated. Impairment of venous drainage may also compromise the arterial blood flow and cause bowel ischemia and infarction.

On contrast-enhanced CT, thrombus in the mesenteric and portal veins is usually visible, and mesenteric venous obstruction can be confirmed by CT in more than 90% of cases [45-47]. Engorgement of the mesenteric veins is also observed. Fat stranding in the mesentery and ascites are common findings. The bowel wall is prominently thickened with absent or diminished enhancement, hyper-enhancement, or a halo or target pattern of contrast enhancement. Absent or diminished contrast enhancement of the bowel wall usually indicates transmural infarction particularly when it is associated with pneumatosis and porto-mesenteric venous gas .On the contrary, the degree of bowel wall thickening, mesenteric fat stranding or ascites does not correlate with the severity of ischemic bowel damage .

Strangulating Obstruction: Closed-Loop Bowel Obstruction

Strangulating obstruction is a mechanical bowel obstruction associated with bowel ischemia that is seen in approximately 10% of patients with small-bowel obstruction [48, 49].

Strangulating obstruction is almost exclusively associated with a closed-loop obstruction, which is caused most often by an adhesive band and occasionally by an internal or external hernia. A closed-loop obstruction tends to involve the mesentery and mesenteric vessels and is prone to produce a volvulus. Typically, strangulation in a closed-loop bowel

obstruction is caused initially by impairment of venous outflow followed by arterial ischemia because the arterial pressure is higher than the venous pressure. Congestion or haemorrhage in the bowel wall and mesentery occurs, and the affected bowel loops are distended and filled with fluid.

On CT, a closed-loop obstruction is identified by a unique configuration of C- or U-shaped distended loops with the mesenteric vessels converging toward the site of obstruction. The obstructed site of the closed loops can be located by following the course of the distended bowel loops [50, 51].

The affected bowel is filled almost exclusively with only fluid and no gas. The affected mesentery typically shows a fan shape. In cases with strangulation, the bowel wall is thickened and shows absent or diminished enhancement, hyper-enhancement, or a halo or target pattern of enhancement on contrast enhanced CT examination.

The affected mesentery shows infiltration and stranding associated with engorged mesenteric veins. Ascites is also observed.

CT performance in diagnosing strangulation is reported as 83–100% in sensitivity, 61–93% in specificity, 72–88% in positive predictive value, and 93–100% in negative predictive value [52-55], although a relatively low sensitivity of 51.9% has been reported recently. The diagnosis of strangulation is based on the characteristic findings described earlier or their combination. Among those findings, absent or diminished bowel wall enhancement and infiltration of the affected mesentery are highly specific. The “small-bowel faeces sign” is also reported as a useful finding indicating the presence of strangulation.

Hypo-perfusion Associated with Non-Occlusive Vascular Disease

Bowel ischemia and infarction can occur with a reduction of mesenteric blood supply without vascular occlusion, which is called non-occlusive mesenteric ischemia or infarction. This type of bowel ischemia accounts for 20–30% of all acute mesenteric ischemia or infarction cases, with mortality rates from 30% to 93% [56, 57]. A reduction of the mesenteric blood supply is the result of mesenteric arterial vasoconstriction on reflex to hypotension or administration or abuse of digitalis, ergotamine, vasopressin or other vaso-constrictive agents, amphetamine, and cocaine. Ischemic injury may range from reversible superficial damage localized to the watershed areas to a more severe form that extends to the entire bowel.

Hypo-perfusion results in increased vascular permeability that leads to extravascular leakage of plasma, RBCs, or both into the bowel wall, mesentery, and peritoneal cavity.

Shock bowel is a variation of non-occlusive mesenteric ischemia caused by hypotensive shock induced by blunt abdominal trauma. Ischemic colitis and obstructive colitis are considered similar disease entities. On CT, the bowel wall of the involved segments may be normal or thickened. The pattern of enhancement is variable as absent or diminished enhancement, increased enhancement, or halo or target type of enhancement. Fat stranding of the mesentery and ascites are visible.

Among various conditions of mesenteric ischemia, non-occlusive mesenteric ischemia is the most difficult condition to diagnose on CT, and angiography is often required for correct and confident diagnosis.

The prognosis for patients with acute mesenteric ischemia depends on the time to diagnosis and initiation of management. The mortality rate ranges

from 0% to 10% with immediate management, increases to 50%–60% with a treatment delay of 6–12 hours, and increases further to 80%–100% with a delay of more than 24 hours after symptom onset. Therefore, early diagnosis and prompt management are mandatory in patients with acute mesenteric ischemia.

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Therefore, for patients with suspected AMI, contrast-enhanced multi-detector CT should be the first-line imaging modality for correct diagnosis and to exclude other causes of acute abdomen. Interpretation of CT images should include accurate assessment of the mesenteric arteries and veins, bowel wall thickness, the presence or absence of bowel wall enhancement, patterns of bowel enhancement, abnormalities in the mesentery and peritoneum, and the presence or absence of ascites and extra bowel gas. The severity of the condition and the viability of the bowel should be carefully appreciated with consideration of the underlying cause, as CT findings vary depending on the pathophysiology and the presence of associated complications.

Management of AMI includes restoration of blood flow and resection of the necrotic bowel. In case the patient is not fit for surgery, medical management with antibiotics and anticoagulant drugs should be done.

AIMS AND OBJECTIVES OF THE STUDY

1. To assess the efficacy of Multi-Detector Computed Tomography (MDCT) in the diagnosis of acute mesenteric ischemia
2. To correlate it with surgical and/or clinical outcome

Review of literature

1. Taourel et al (1996) conducted a study to evaluate the accuracy of MDCT in the diagnosis of acute mesenteric ischemia. Reviewers blinded to patient diagnosis retrospectively compared the CT scans in a study group with those in a control group. The study group comprised 39 patients (23 men, 16 women; aged 55-88 years) with surgically proven acute mesenteric ischemia. The control group comprised of 24 patients (13 men, 11 women; aged 50-82 years) with suspected acute mesenteric ischemia that was disproved at surgery. For the diagnosis of acute mesenteric ischemia, each of the following findings had a specificity of more than 95% and a sensitivity of less than 30%: arterial or venous thrombosis, intramural gas, portal venous gas, focal lack of bowel-wall enhancement, and liver or splenic infarcts. When CT was used in the diagnosis of suspected acute mesenteric ischemia, the detection of at least one of these signs resulted in a sensitivity of 64% (25 of 39; confidence interval, 0.49, 0.79), a specificity of 92% (22 of 24; confidence interval, 0.81, 1.00), and an accuracy of 75% (47 of 63; confidence interval, 0.64, 0.86). Therefore, conclusion was made that MDCT is a valuable tool in the diagnosis of and determination of prognosis in acute mesenteric ischemia [58].
2. Kirkpatrick et al (2003) conducted a study to evaluate the sensitivity and specificity of biphasic computed tomography (CT) with mesenteric CT angiography in the diagnosis of acute mesenteric ischemia (AMI). Study was conducted on sixty-two patients with clinically suspected AMI who underwent radiological imaging with biphasic multi-detector row CT. In this study Mesenteric CT angiography was performed with 1.25-mm collimation starting 25 seconds after 140 mL of intravenous contrast agent was administered at a rate of 4 mL/sec, followed by portal venous phase imaging with 5-mm collimation and a 60-70-second delay. CT angiograms were reconstructed with multiplanar (including transverse), maximum

intensity projection, and volume-rendered techniques. All scans were evaluated prospectively by two independent radiologists for CT evidence of ischemia. AMI was confirmed with surgical or pathologic proof in 25 of 26 patients. In one patient, AMI was confirmed with clinical findings and serial CT examinations. In patients with AMI, sensitivity and specificity of each CT sign were calculated retrospectively by using patients who did not have intestinal ischemia as a control group. In the study AMI was diagnosed in 26 patients. The CT angiogram depicted arterial disease in eight patients. In study a finding of any one of pneumatosis intestinalis, venous gas, superior mesenteric artery occlusion, celiac and inferior mesenteric artery occlusion with distal SMA disease, or arterial embolism was 100% specific but only 73% sensitive. Alternatively, a finding of bowel wall thickening in addition to focal lack of bowel wall enhancement, solid organ infarction, or venous thrombosis was 50% sensitive and 94% specific. Using either of these criteria for the diagnosis, a sensitivity of 96% and a specificity of 94% was achieved. Study concluded that biphasic CT with mesenteric CT angiography is effective in the diagnosis of AMI [59].

3. Haghighi et al. 2008 conducted a study in which patient records of public and private hospitals with clinical diagnosis of acute abdomen were reviewed. Among the 10000 patients records studied, 105 patients were identified with Acute Mesenteric Ischemia. The mortality rate among them was 50.4%. The most common symptom in these patients was pain in the abdomen. The mortality rate was lower in those patients who underwent MDCT [2].
4. Aschoff et al (2009) conducted a study for the evaluation of accuracy of biphasic mesenteric multi-detector CT angiography in diagnosis of acute mesenteric ischemia. In the study, total 79 consecutive patients with clinical signs of AMI underwent contrast enhanced 16- or 40-channel MDCT. MDCT findings were correlated with surgery, endoscopy and clinical outcome. Sensitivity, specificity, and positive and negative

predictive values were calculated using the patients in which AMI had been excluded as a control group. In 28 patients the final diagnosis was AMI. In 27 patients (96.4%) MDCT correctly diagnosed AMI (specificity of 97.9%). A sensitivity of 93%, specificity of 100%, and positive and negative predictive values of 100% and 94%, respectively were achieved for the CT findings of visceral artery occlusion, intestinal pneumatosis, porto-mesenteric venous gas or bowel wall thickening in combination with either porto-mesenteric thrombosis or solid organ infarction. Study findings suggested that mesenteric MDCT angiography is an accurate tool for diagnostic work-up of patients with suspected AMI [60].

5. Wadman et al (2010) conducted a study to assess the role of multi-detector computerised tomography with intravenous contrast enhancement in improving the diagnostic accuracy and survival in patients of acute mesenteric ischemia. Patients with acute SMA occlusion were identified and medical records were analysed. A total of 67 patients were identified with SMA occlusion, of which 36 were examined with contrast enhanced MDCT and ten with plain MDCT without intravenous contrast. In all, 24 (67%) of the 36 patients were correctly diagnosed by contrast enhanced MDCT at first evaluation. Clinical suspicion of intestinal ischemia followed by a distinct inquiry for intestinal ischemia was associated with trend for a higher rate of correct radiological diagnosis. At re-evaluation, SMA occlusion was found in all cases with contrast enhanced MDCT, whereas intestinal findings were present in half. In-hospital mortality rate was 42% for patients who underwent contrast enhanced MDCT, which was significantly lower compared to 90% for the ten patients examined with plain MDCT (p=0.007) and 71% for patients not examined with contrast enhanced MDCT or plain MDCT (p=0.031). Patients that underwent plain MDCT had higher levels of creatinine compared to those examined with MDCTiv (p=0.005). Examination with contrast enhanced MDCT in patients with acute SMA occlusion was associated with survival benefit. Hence, contrast enhanced MDCT seems

to be the method of choice for the diagnosis of acute mesenteric ischemia [61].

6. Barmase M et al (2011) conducted a study to assess the role of multidetector CT angiography (MDCTA) in the diagnosis of acute mesenteric ischemia (AMI) and to compare the diagnostic utility of axial images with reconstructed images. In this prospective study, MDCTA was performed on 31 patients who presented with the clinical suspicion of AMI (25M; 6F, age range: 16-73 years). Axial and reconstructed images of each patient were evaluated independently by two radiologists for evidence of bowel wall thickening, abnormal mucosal enhancement, bowel dilatation or obstruction, mesenteric stranding, ascites, solid organ infarcts, pneumatosis intestinalis or porto-mesenteric gas, and mesenteric arterial or venous occlusion. MDCT findings were correlated with the surgical findings and clinical outcome. Patients were later divided into two groups: a study group of patients with proven AMI and a control group of patients with an alternate diagnosis, for the purpose of statistical analysis. AMI was correctly diagnosed in all 16 patients on MDCTA (100% sensitivity and specificity) of whom nine patients underwent surgical exploration. Three patients expired before surgery and the remaining 5 patients were proven based on positive clinical and laboratory findings. Mesenteric arterial occlusion was seen in 7 patients while 5 patients had porto-mesenteric venous thrombosis. Reconstructed images using minimum intensity projection, volume rendering and multiplanar volume reconstruction were found to perform better for the detection of vascular abnormalities and improved the diagnostic confidence of both radiologists in the evaluation of bowel and mesenteric abnormalities. It was concluded that MDCTA is an effective non-invasive modality for the diagnosis of mesenteric ischemia [62].
7. Yikilmaz et al (2011) conducted a study to define the value of multi-slice computed tomography (CT) in the diagnosis of acute mesenteric ischemia (AMI). In this study, two hundred patients (age range: 20-92 years) who

were referred to the emergency CT department with a clinical suspicion of AMI were included in the study. CT examinations were performed with a multi-slice (16) CT scanner and the protocol included were pre-contrast, arterial and venous phase acquisitions. Images were evaluated by using multiplanar reconstruction, maximum intensity projection and volume-rendering techniques. In this study, ninety-four patients (47%) underwent surgery for AMI or for other causes of acute abdominal pain. One hundred-six patients (53%) were followed conservatively according to clinical, radiologic and laboratory findings. Of the 94 patients who underwent surgery, 49 (25%) were found to have AMI. All of these 49 patients with a proven AMI diagnosis were diagnosed with CT. In the other 45 patients who underwent surgery, CT findings were negative for AMI. None of the patients, who were followed conservatively, were eventually diagnosed as having AMI except 1 patient. This patient was unfit for surgery although his clinical and radiologic findings were consistent with AMI and died in 3 days. The sensitivity and specificity values of CT for the detection of AMI were calculated to be 100% for each. The study found that multi-slice CT is an effective imaging technique for the diagnosis of AMI with excellent sensitivity and specificity values [63].

8. Another study was conducted by Azzazy et al 2012, to evaluate the role of multi detector CT in assessment of mesenteric ischemia in clinically suspected patients. This study included 38 patients during period from October 2009 to October 2011. The patients age ranged from 38 to 72 year old (mean age was 57 ± 11.2 years). All cases met the criteria of acute (28 patients) or chronic abdominal pain (10 patients) and suspected mesenteric ischemia. All 38 cases were evaluated in surgery department, underwent CT abdomen and pelvis & CTA by using 64 multi slice GE light speed CT. MDCT findings were correlated with surgical findings in acute mesenteric ischemia (AMI) cases. The sensitivity, specificity & accuracy of CTA in diagnosis of AMI after surgical confirmation were 96%, 66.6% &

92.8% respectively. It was concluded that MDCT is an excellent tool to find out and localize causes of AMI [64].

9. Aouini F et al (2012) performed a retrospective study to review the clinical data of patients hospitalized with acute mesenteric ischemia. Analysis of the factors that could influence mortality was conducted. 26 patients, predominantly male of mean age of 60 years, were included. These patients were cared for on average 4 days after the onset of symptoms. The diagnosis was made pre-operatively in 9 patients, by CT scan in 8 patients and by Doppler ultrasound in 1 patient. The cause of AMI was arterial thrombosis in 19 cases, venous thrombosis in 4 cases and non occlusive mesenteric ischemia in 3 cases. 25 patients were operated on emergency 24 times by a laparotomy and one time by a laparoscopy. The surgery consisted in bowel resection in 15 patients; an abstention was decided in one case of venous mesenteric ischemia and in 9 cases where necrosis affected all small bowels. Revascularization of the superior mesenteric artery was associated in 4 cases. Outcome was simple in 8 patients. The mortality rate was 69% after surgery. This rate wasn't influenced by age or sex. It was higher in patients with preoperative collapse ($p = 0.02$) and having an expansive bowel necrosis ($p=.0001$). The prognosis was better in cases of venous infarction with a mortality rate of zero. It concluded that prognosis of acute mesenteric ischemia depends on the aetiology and the quickness of treatment [65].
10. Mazzei et al. (2012) conducted study to evaluate the computed tomographic appearances of mesentery in acute mesenteric ischemia (AMI) to recognize characteristic features and their prognostic values. In this retrospective study computed tomographic examinations of 34 patients with a confirmed diagnosis of AMI were retrospectively reviewed to evaluate the number of mesenteric vessels, diameter of the superior mesenteric artery and superior mesenteric vein, mesenteric fat stranding, mesenteric vessel pneumatosis and ascites. Study found that at least one of these mesenteric signs was present except 1 patient. In all AMI of

arterial occlusive type and in 68% of non-occlusive mesenteric ischemia, the number of arterial vessels was reduced (P = 0.067). Mesenteric vessel pneumatosis and reduced number of venous vessels were significantly associated with higher mortality (P = 0.027 and P = 0.042, respectively). Reperfusion signs were associated with a reduced mortality (28.7% vs 65.5%). Considering its characteristic features and its possible prognostic value, the evaluation of mesentery will supply additional information in the interpretation of computed tomography in AMI [66].

11. ALHAN et al. 2012 conducted a study on 107 patients with acute mesenteric ischemia over 30 years. The clinical records of all the patients who underwent surgical treatment for AMI due to arterial embolism, thrombosis , non-occlusive mesenteric ischemia (NOMI) were examined. Patient's demographics, co-morbidity, physical findings, laboratory test results, and diagnostic imaging reports were reviewed. Initial admission laboratory test results were taken into account. The data from operative records postoperative complications, second-look laparotomies, mortality (in-hospital mortality after surgical treatment) and hospital stay were recorded. Based on clinical, radiological, surgical and histological findings, patients were classified as having mesenteric emboli, arterial or venous thrombosis or a NOMI.They identified the risk factors that predicted the adverse outcome of Acute Mesenteric Ischemia Hospital records and clinical data of 107 patients undergoing surgical intervention for Acute Mesenteric Ischemia during the last 30 years were reviewed and clinical outcomes as well as factors influencing mortality were analyzed. Sixty eight patients were men (63.6%) and 39 were women (36.4). The mean ± SD age was 69 ± 8 with the range of 39–92 years. Superior mesenteric artery (SMA) thrombosis was the most common form of AMI and was seen in 68 patients (68.6). 28 patients (26.2%) had SMA embolism, and 11 patients (10.2%) had NOMI, mesenteric arterial thrombosis, arterial embolism and non occlusive mesenteric ischemia were responsible for Acute Mesenteric Ischemia in

68, 28 and 11 patients respectively. Abdominal pain was the most common presenting feature (90.6%).Peritonitis was observed in 96 patients and 24 patients were in shock. Abdominal ultrasound was performed in 46 patients, abdominal MDCT was done in 36 patients. All patients underwent surgery and 11 patients underwent second look operation .Bowel resection was done in 101 patients during the initial operation and in 7 patients during second look operation .The hospital mortality was 55.1%. MDCT was found to be a protective factor against mortality [67].

12. Geffroy et al (2014) conducted a study to evaluate performance of increased bowel-wall attenuation on unenhanced 64-section multidetector computed tomographic (CT) images for diagnosing bowel wall ischemia in patients with mechanical small-bowel obstruction (SBO) and to evaluate the diagnostic accuracy of multidetector CT in detecting small-bowel ischemia complicating SBO, with surgical and histopathologic findings as reference standard. In this study, 44 patients (10 men, 34 women; age range, 30-100 years) who were admitted because they were suspected of having SBO and treated surgically within the next 7 days, 45 multidetector CT scans were retrospectively reviewed and were compared with both findings in prospective radiology reports and surgical and histopathologic findings. In 19 of 45 (42%) multidetector CT scans, ischemia was confirmed at surgery and/or histopathologic examination. Increased bowel-wall attenuation on unenhanced images was significantly associated with ischemia ($P < .0001$); in this highly selected population, this sign had a 100% (24 of 24) specificity and a 56% (10 of 18) sensitivity. Sensitivity and specificity of multidetector CT for ischemia were 63% (12 of 19) and 92% (24 of 26), respectively, for the prospective reports and 84% (16 of 19) and 96% (25 of 26), respectively, for the consensus review. Decreased segmental bowel-wall enhancement was the most accurate 64-section multidetector CT sign for diagnosing ischemia (sensitivity, 78% [14 of 18]; specificity, 96% [24 of 25]; $P < .0001$). The

small-bowel faeces sign was significantly associated with ischemia (P=.0308). It was concluded that increased bowel-wall attenuation on unenhanced 64-section multidetector CT images is a specific sign for ischemia complicating SBO. Diagnostic accuracy of 64-section multidetector CT for ischemia associated with SBO was excellent [68].

13. Lehtimäki TT et al (2015) conducted a study on 95 patients treated for AMI . A retrospective study of 95 consecutive patients treated for 97 AMI events was carried out. The etiology of AMI was embolism in 24 (25%), atherosclerotic vascular disease (ASVD) in 39 (40%), non-obstructive mesenteric ischemia (NOMI) in 25 (26%), and mesenteric venous thrombosis (MVT) in nine (9%) cases. The protocols, referrals and initial radiology reports of the abdominal CTs were analyzed. The CT studies were further scrutinized for vascular and intestinal findings. The referring clinician had suspected AMI in 30 (31%) cases prior to imaging. The crucial findings of AMI had been stated in 97% of the radiology reports if the clinician had mentioned AMI suspicion in the referral; if not, the corresponding rate was 81% (p=0.04). Patients without suspicion of AMI prior to CT were more prone to undergo bowel resection. CT protocol was optimal for AMI (with contrast enhancement in arterial and venous phases) in only 34 (35%) cases. Intestinal findings were more difficult to detect than vascular findings. Vascular findings were retrospectively detectable in 92% of cases with embolism and 100% in ASVD and MVT. Some evidence of intestinal abnormality was retrospectively found in the CT findings in 92%, 100%, 100% and 67% of cases with embolism, ASVD, NOMI and MVT, respectively [69].
14. Chandrasekhar (2018) conducted a study to assess the cases of acute mesenteric ischemia with MDCT. Study was conducted on 32 cases of mesenteric ischemia of both genders. All patients underwent MDCT examination with 128 detector rows Siemens definition AS scanner. Out of 32 patients, 18 lesions were acute which comprised of 10 males and 8 females and in 14 chronic lesions, 8 males and 6 females. The difference

was non- significant (P< 0.05). MDCT shows bowel wall thickening in males (14) and females (12), bowel distension in 8 males and 7 females, SMA dissection in 7 males and 8 females and pneumatosis in 5 males and females 6. The difference was non- significant (P> 0.05). Authors found MDCT a useful diagnostic tool in diagnosis of cases of mesenteric ischemia as it provided excellent evaluation of vascular structures [70].

15. Abdulkareem et al (2019) conducted a study on 50 patients with mesenteric ischemia diagnosed at laparotomy. Mode of presentation, age, sex, predisposing conditions, diagnostic modalities, operative findings and type of operative procedure performed were all studied and analyzed. There were (24) males and (26) females. Male: female ratio was about 0.9:1, the commonest age groups presented were first between 25 – 35 years (14 patients) and second between 46 – 55 years (16 patients). The main presentation was abdominal pain and gastrointestinal bleeding (33 cases), with a mortality rate of (64.5%). The main physical finding was patient with signs of peritoneal irritation (38 patients) which carries lower mortality rate (21%), while the highest mortality rate was seen in those having combined features of peritoneal irritation and hemodynamic instability (87.5%). The time interval between hospital admission and time of surgery ranged from < 24 – 244 hours with a mean =22 patients have two or more predisposing conditions like hypertension, diabetes, ischemic heart disease and atrial fibrillation. Different types of diagnostic modalities were performed, CT scan carried high diagnostic accuracy rate (100%). The commonest operative findings were focal segmental ischemia (38 cases) explaining the most frequent operative procedure performed which is resection with end to end anastomosis (32 cases) [71].

MATERIALS AND METHODS

SOURCE OF DATA

This study was conducted over a period of one and a half year on the patients with Acute Mesenteric Ischemia referred for MDCT Abdomen to the Department of Radio-diagnosis, Dayanand Medical College & Hospital, Ludhiana.

METHOD OF COLLECTION OF DATA

This was a prospective study conducted on patients with Acute Mesenteric Ischemia referred for MDCT Abdomen to the Department of Radio-diagnosis, Dayanand Medical College & Hospital, Ludhiana over a period of one and half year.

Informed consent was obtained from all the subjects /guardians before study. The clinical history regarding the onset of symptoms, clinical progression of disease and spectrum of findings were recorded. MDCT of the patients was performed on Siemens 128 slice CT scan machine after giving intravenous omnipaque contrast.

PREPARATION OF PATIENT

The procedure was explained to the patient in his/her vernacular language to alleviate fear and anxiety. During the entire period of the procedure patient was in contact with the technician/doctor by a two-way intercom system.

MDCT Protocol for the image acquisition was as follow:

Scan was performed with the patient in supine position in quiet respiration. I.V contrast study using non-ionic water soluble contrast medium was done following plain study.

- Scan duration: 90 seconds with scanning delay time of 30 seconds for arterial phase and 60 seconds for venous phase.
- Scan area of interest: dome of diaphragm to pubic symphysis
- Direction of scan: cranio-caudal
- Collimation: 128*0.6 mm
- Pitch: 0.8
- Reconstructed Slice thickness: 1mm
- Amount of contrast given and injection rate: 1.5ml/kg body weight at the rate of 3 ml/sec
- FOV(field of view): 400-750 mm
- Current : 175mAS
- Voltage: 120 kV

Study design

This was a longitudinal, prospective study

Inclusion criteria

1. Findings of acute mesenteric ischemia on Multi-Detector Computed Tomography (MDCT) Abdomen.
2. Patients with negative imaging examination who subsequently found to have features of acute mesenteric ischemia per-operatively.

Exclusion criteria

1. Patients with alternative diagnosis of acute abdomen on imaging .
2. Patients who refused to participate in the study.

MDCT images interpretation:

1. Bowel wall thickness: Thickness of >3 mm in small or large bowel was considered as a criteria for bowel wall thickening in non-collapsed gut loop.
2. Lack of bowel wall enhancement
3. Increased bowel wall attenuation on non contrast imaging
4. Bowel dilatation: By definition, small bowel diameter of more than 2.5 cm and large bowel diameter of more than 6 cm was considered as criteria for bowel dilatation.
5. Arterial or venous thrombosis
6. Mesenteric fat stranding
7. Free fluid/ascites
8. Intestinal pneumatosis
9. Porto-mesenteric venous gas
10. Solid organ infarction

The radiological data describing the vascular & intestinal findings systematically were collected and the diagnostic findings of AMI were correlated with surgical data and histopathological findings.

OBSERVATIONS AND RESULTS

1. DEMOGRAPHIC DATA

40 patients were evaluated in this study ranging from 28-93 years

The mean age of population in our study was 56.6 ± 17.9 years.

Maximum patients (n=9, 22.5%) were between 41-50 years of age followed by 7 cases (17.5%) each between 31-40 years and 61-70 years of age (Table 1, Figure 3). 23 (57.5%) were males and rest 17 (42.5%) were females (Table 2, Figure 4)

Table 1: Age distribution of patients

AGE	No. of cases	Percentage
< 30	2	5.0%
31-40	7	17.5%
41-50	9	22.5%
51-60	6	15.0%
61-70	7	17.5%
71-80	3	7.5%
> 80	6	15.0%
Total	40	100.0%

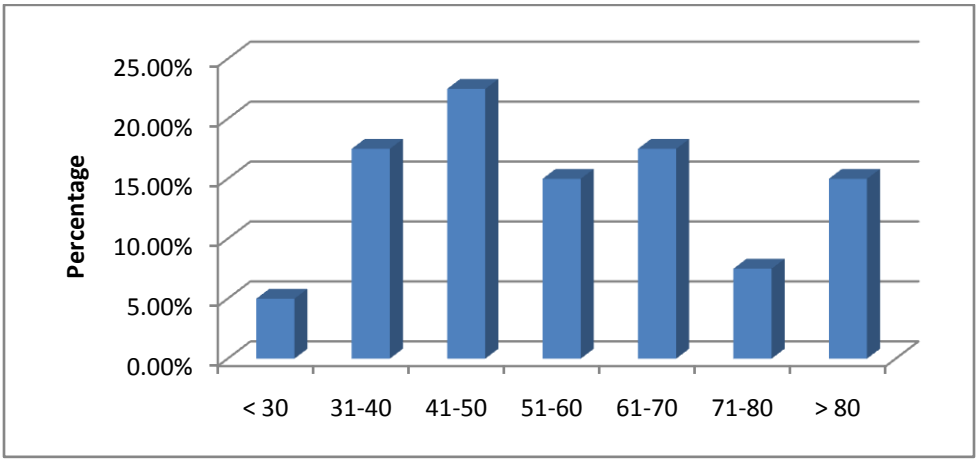


Figure 3: shows age group distribution (years) with percentage of cases

Table 2: Gender distribution of patients

SEX	No. of cases	Percentage
M	23	57.5%
F	17	42.5%
Total	40	100.0%

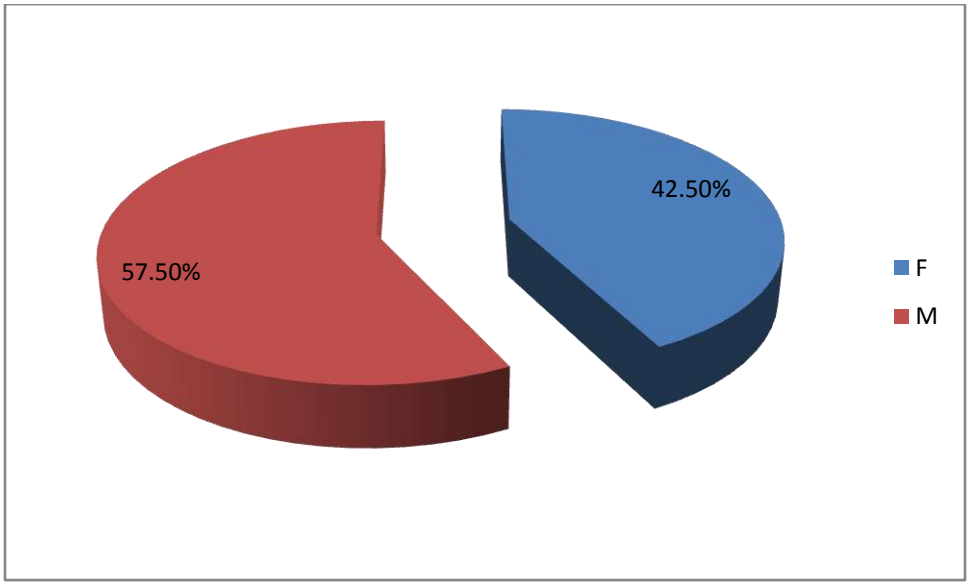


Figure 4: showing pie chart distribution of males and females

2. CLINICAL SYMPTOMS

Out of 40 patients , 38 (95%) patients presented with pain abdomen.26 (65%) patients presented with constipation, 20 (50%) patients presented with vomiting. 20 (50%) patients presented with abdominal distension. only 3 (7.5%) patients presented with blood in stools(table 3a- 3e,Figure 5-9)

Table 3a: Clinical presentation of the patients with pain abdomen

PAIN ABDOMEN	No. of cases	Percentage
YES	38	95.0%
NO	2	5.0%
Total	40	100.0%

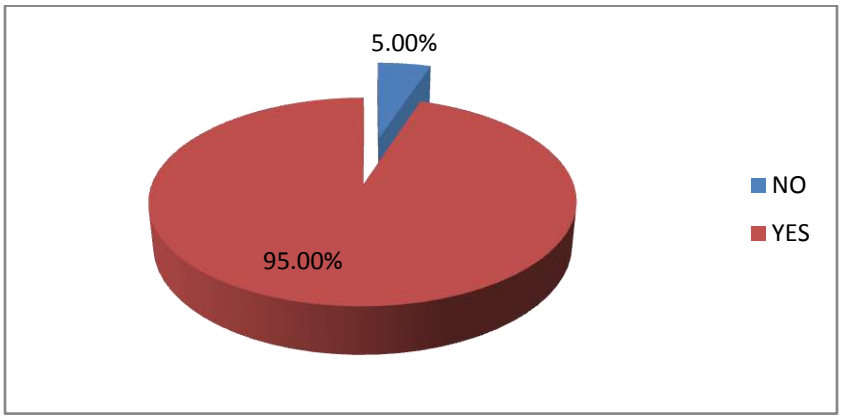


Figure 5: showing percentage of patients presenting with pain abdomen

Table 3b: Clinical presentation of patients with constipation

CONSTIPATION	No. of cases	Percentage
YES	26	65.0%
NO	14	35.0%
Total	40	100.0%

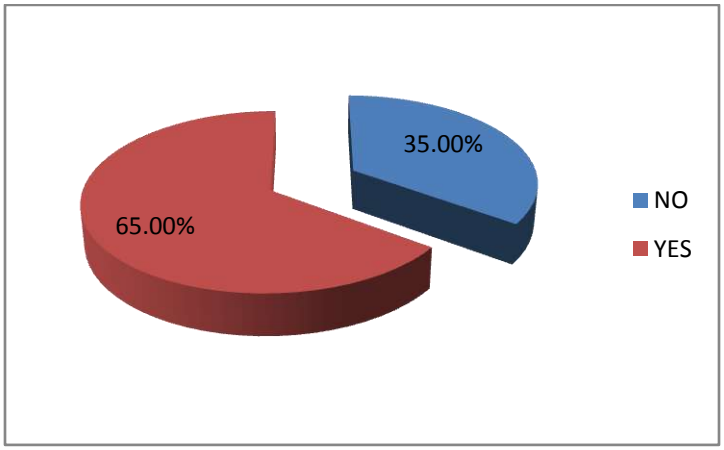


Figure 6: showing distribution of patients presenting with constipation.

Table 3c: Clinical presentation of patients with vomiting

VOMITING	No. of cases	Percentage
YES	20	50.0%
NO	20	50.0%
Total	40	100.0%

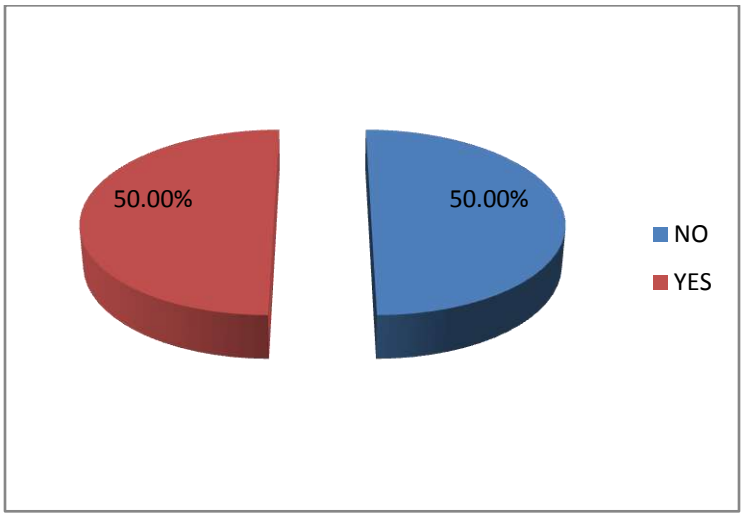


Figure 7: showing distribution of patients presenting with vomiting

Table 3d: Clinical presentation with abdominal distension

ABDOMINAL DISTENSION	No. of cases	Percentage
YES	20	50.0%
NO	20	50.0%
Total	40	100.0%

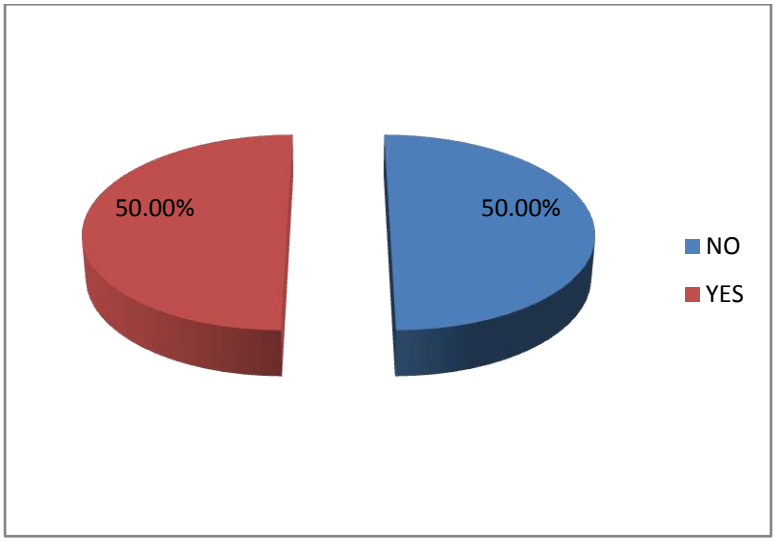


Figure 8: showing distribution of patients with abdominal distension

Table 3e: Clinical presentation of patients with blood in stools

BLOOD IN STOOLS	No. of cases	Percentage
NO	37	92.5%
YES	3	7.5%
Total	40	100.0%

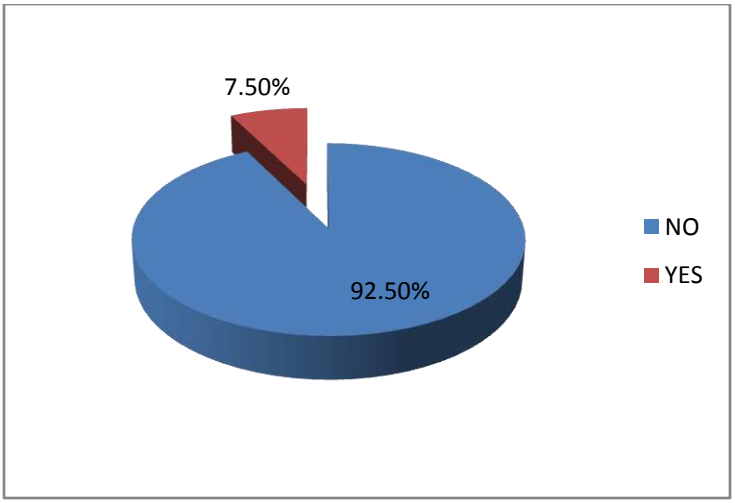


Figure 9: showing distribution of patients with blood in stools

3. CLINICAL DIAGNOSIS

Out of 40 patients, on the basis of clinical complaints, clinical diagnosis of acute mesenteric ischemia was made only in 13 patients (32.5%). In other 27 patients, 14 (35%) were diagnosed as subacute intestinal obstruction clinically, 1(2.5%) patient was diagnosed as acute colitis , 3 (7.5%) patients were diagnosed as acute gastritis, and 4 (10%) were diagnosed as acute pancreatitis(table 4, Figure10)

Table 4: Clinical diagnosis

CLINICAL DIAGNOSIS	No. of cases	Percentage
SUBACUTE INTESTINAL OBSTRUCTION	14	35%
ACUTE MESENTERIC ISCHEMIA	13	32.5%
ACUTE PANCREATITIS	4	10.0%
ACUTE GASTRITIS	3	7.5%
ACUTE ABDOMEN	2	5.0%
ACUTE COLITIS	1	2.5%
CHRONIC LIVER DISEASE	1	2.5%
INGUINAL HERNIA	1	2.5%
INTESTINAL PERFORATION	1	2.5%
TOTAL	40	100.0%

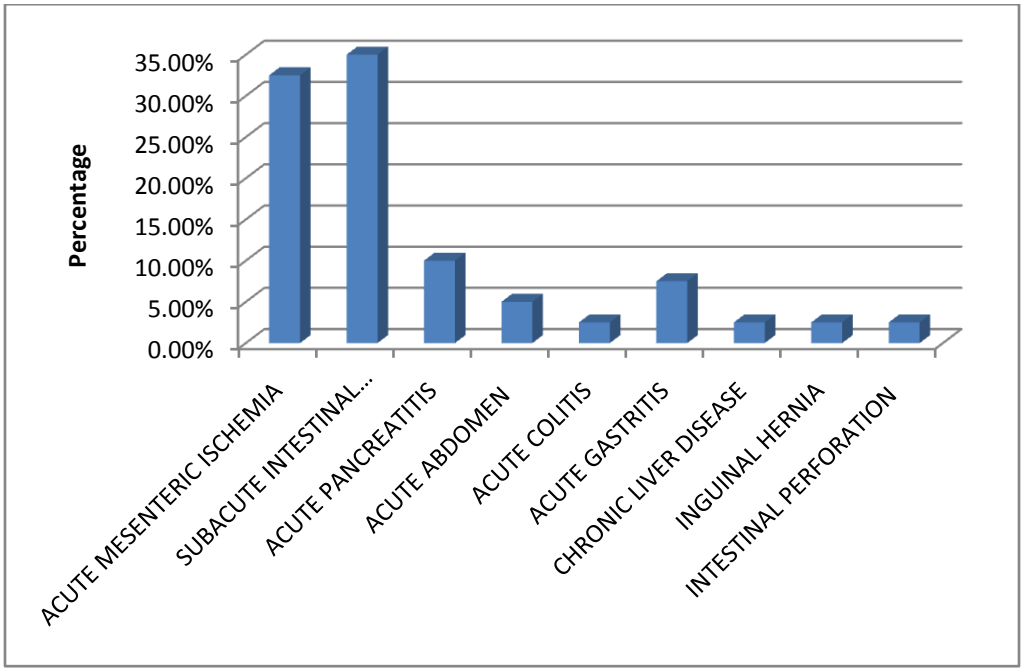


Figure 10: showing distribution of patients with various clinical diagnosis

4. LAB INVESTIGATIONS

In all 40 patients, TLC was done .Out of these, 24 (60%) patients were having leucocytosis, rest 16 (40%) patients were having TLC within normal range (table 5a, Figure11). Mean TLC was 13 ± 6.6. Serum lactate was done only in 16 patients out of which it was more than 2 in 9 (56.2%) patients. In 7 (43.7%) patients, serum lactate levels were less than 2 (table 5b, Figure12) .

Table 5a: Lab investigations showing TLC values in all patients

TLC	No. of cases	Percentage
>11000	24	60.0%
<11000	16	40.0%
Total	40	100.0%

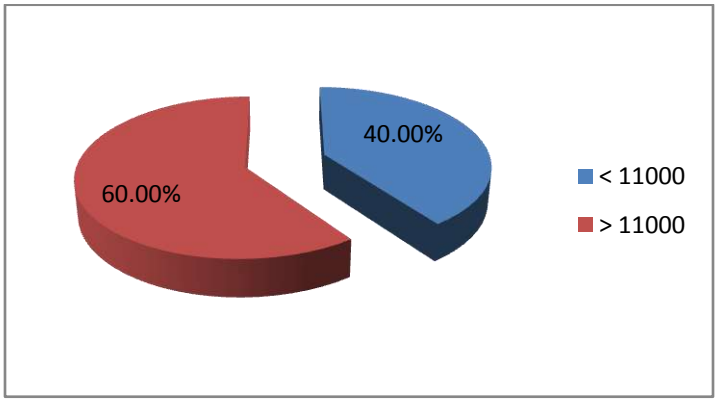


Figure 11: showing distribution of patients showing leucocytosis

Table 5b: Lab investigations showing serum lactate levels

SERUM LACTATE	No. of cases	Percentage
>2	9	56.2%
<2	7	43.7%
TOTAL	16	100.0%

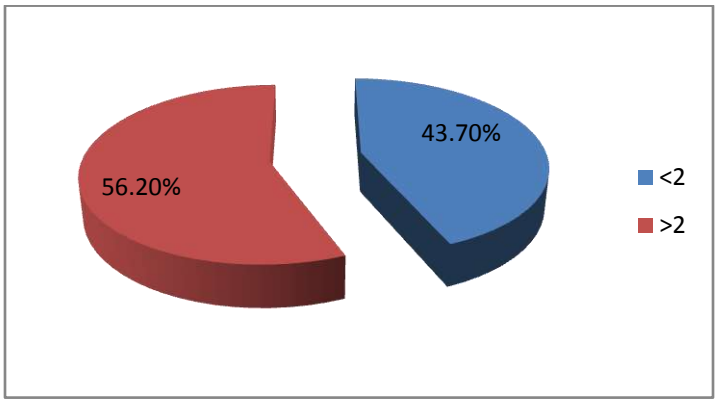


Figure 12: showing distribution of serum lactate levels

5. CO- MORBIDITIES

Out of 40 patients that were included in our study , 27 patients were having prior co morbidities whereas 13 (32.5%) patients were not having any previous co morbid condition. 21 (52.5%) were known case of hypertension, 2(5%) patients were having chronic liver disease, 1(2.5%) patient was known case of atrial fibrillation, 1 (2.5%) was diagnosed with deep vein thrombosis, 1(2.5%) had SLE and 1(2.5%) patient was known case of carcinoma cervix (table 6, Figure13).

Table 6: showing presence of co-morbid conditions

CO MORBIDITY	No. of cases	Percentage
HTN	21	52.5%
CLD	2	5%
ATRIAL FIBRILLATION	1	2.5%
CA CERVIX	1	2.5%
DEEP VEIN THROMBOSIS	1	2.5%
SLE	1	2.5%
NONE	13	32.5%
Total	40	100.0%

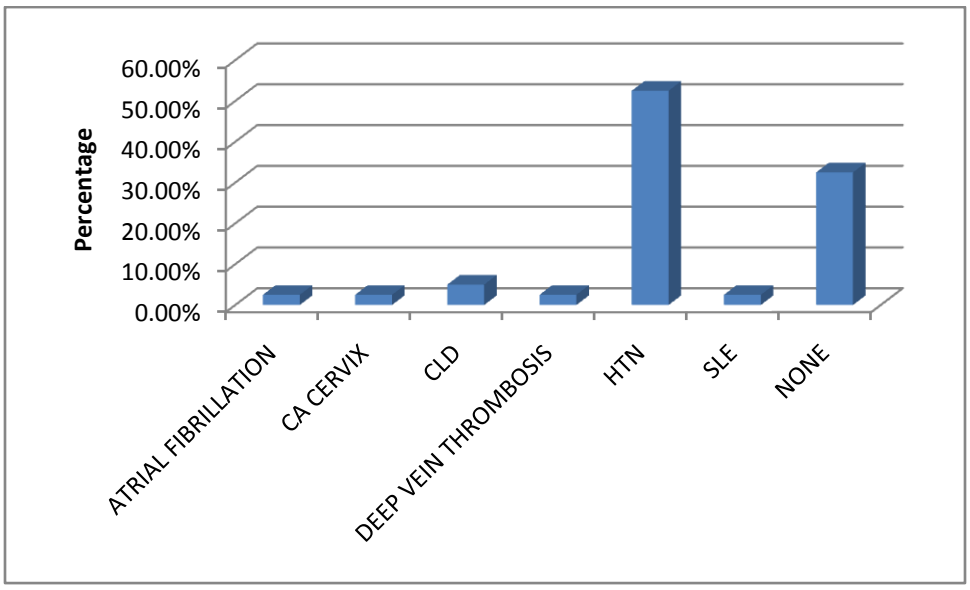


Figure 13: showing distribution of various co morbid conditions

6. CT FINDINGS –

6.1 Bowel wall thickness

Out of 40 patients who underwent CT scan, bowel wall thickening was seen in 25 (62.5%) patients. Thinned out bowel wall was seen in 7(17.5%) patients and in 8 (20%) patients, wall thickness was normal (table 7a, Figure14).

Table 7a: CT findings (bowel wall thickening/thinning)

BOWEL WALL	No. of cases	Percentage
THICKENING	25	62.5%
THINNING	7	17.5%
NORMAL	8	20%
Total	40	100.0%

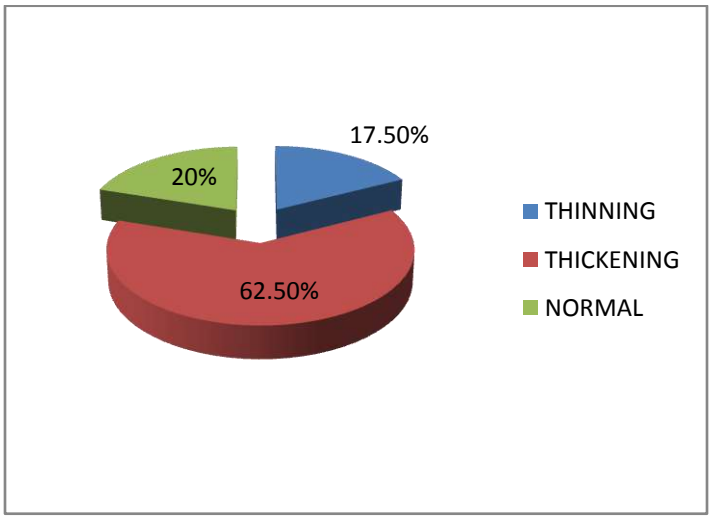


Figure14: showing distribution on basis of bowel wall thickening

6.2 BOWEL WALL ATTENUATION ON NCCT AND WALL ENHANCEMENT ON CONTRAST ENHANCED CT

Out of 40 patients, 8(20%) patients showed hyper attenuating walls on non contrast CT scan. Rest 32(80%) patients showed normal wall attenuation (table 7b, Figure15)

On contrast enhanced CT scan, 13 (32.5%) patients showed non enhancing walls of the involved bowel segment whereas 14 (35%) showed hypo-enhancing walls. Hyper enhancing walls were seen in 3 (7.5%) patients whereas 10(25%) patient showed normal wall enhancement (table 7c, Figure16)

Table 7b: CT findings (bowel wall attenuation on non contrast scan)

WALL ATTENUATION ON NON CONTRAST CT	No. of cases	Percentage
NORMAL	32	80.0%
HYPERATTENUATING	8	20.0%
TOTAL	40	100.0%

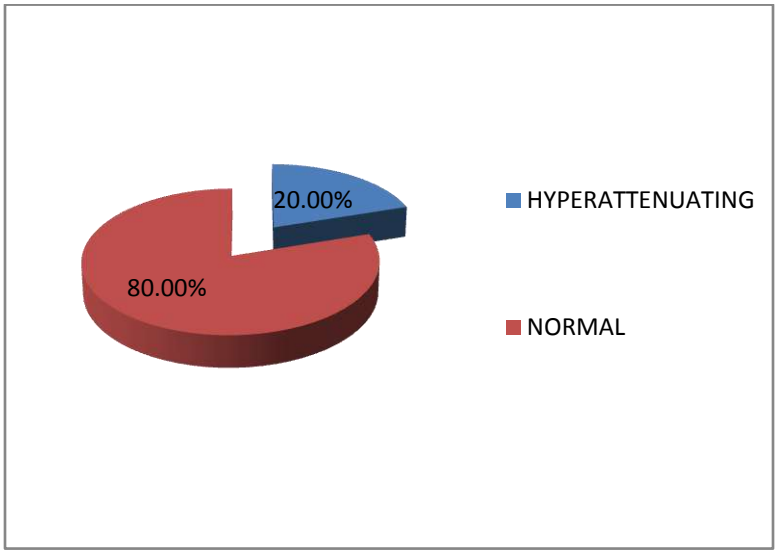


Figure 15: showing distribution on basis of bowel wall attenuation.

Table 7c: CT findings (bowel wall enhancement on post contrast images)

WALL ENHANCEMENT	No. of cases	Percentage
HYPOENHANCING	14	35.0%
NON ENHANCING	13	32.5%
HYPERENHANCING	3	7.5%
NORMAL	10	25.0%
TOTAL	40	100.0%

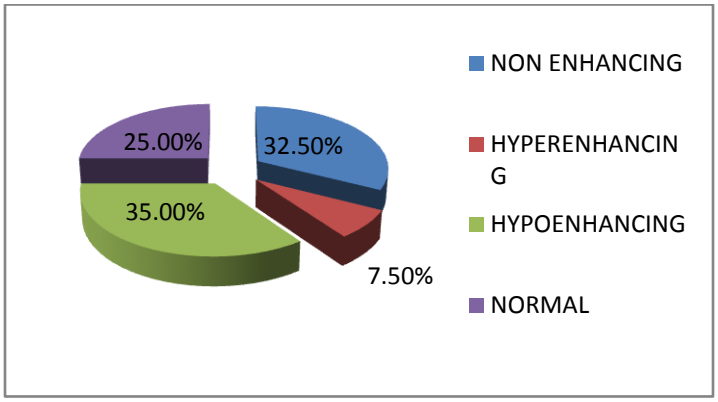


Figure16: showing distribution on basis of bowel wall enhancement.

6.3 BOWEL DILATATION

Out of 40 patients, 28(70%) were having dilatation of bowel lumen on CT abdomen whereas 12(30%) were having normal calibre of the bowel (table 7d, Figure17).

Table 7d: CT findings of bowel dilatation

BOWEL WALL DILATATION	No. of cases	Percentage
YES	28	70.0%
NO	12	30.0%
Total	40	100.0%

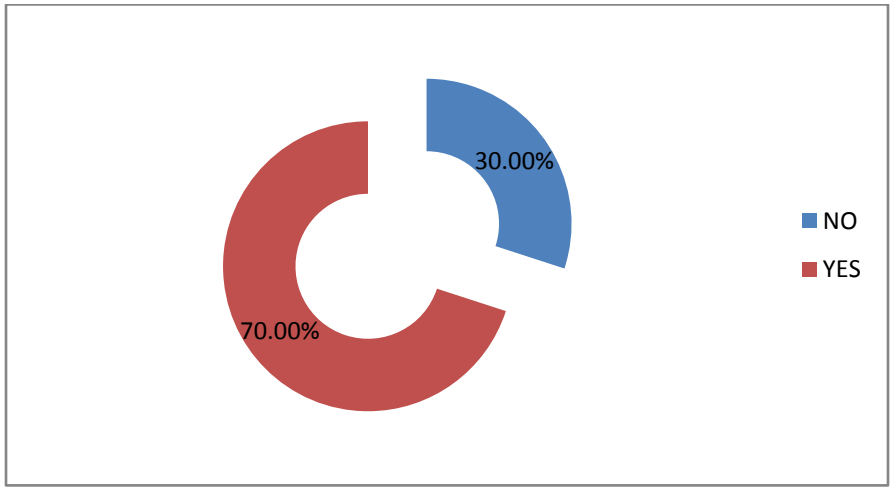


Figure17 showing distribution on basis of bowel dilatation

6.4 MESENTERIC CHANGES

In our study, 38 (95%) patients showed changes in mesentery in the form of fat stranding. Rest 2 (5%) showed no changes in mesentery (table 7e, Figure 18).

Table 7e showing changes in mesentery in all 40 patients

CHANGES IN MESENTRY	No. of cases	Percentage
YES	38	95.0%
NO	2	5.0%
Total	40	100.0%

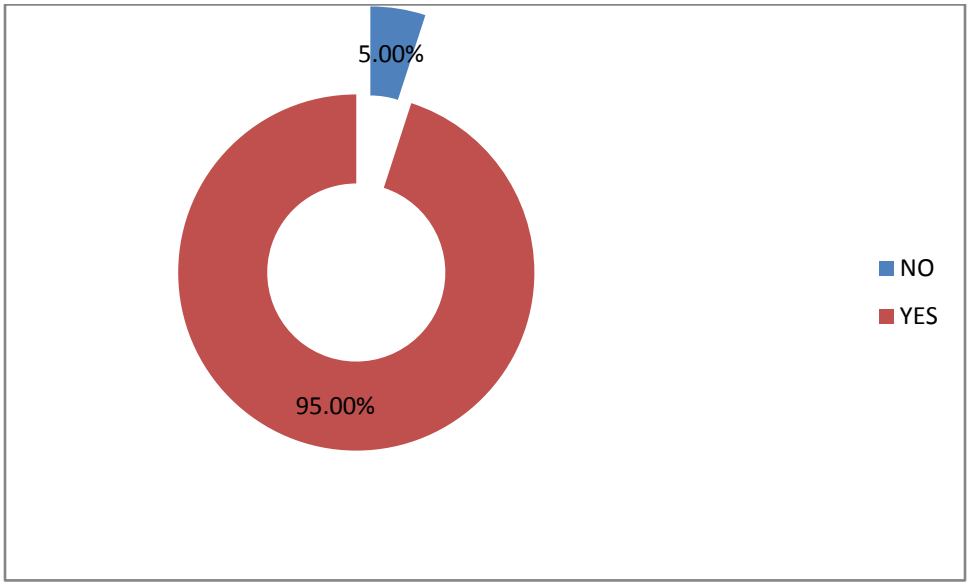


Figure 18: showing distribution of patients with mesenteric changes

6.5 PNEUMATOSIS INTESTINALIS AND PORTO-MESENTERIC PNEUMATOSIS

8 patients (20%) out of 40 showed features of pneumatosis intestinalis and porto-mesenteric pneumatosis on imaging, rest 32 (80%) did not show features of pneumatosis intestinalis or porto-mesenteric pneumatosis (table 7f, Figure 19).

Table 7f: CT findings of pneumatosis intestinalis and porto-mesenteric pneumatosis

PNEUMATOSIS INTESTINALIS AND PORTO-MESENTERIC PNEUMATOSIS	No. of cases	Percentage
NO	32	80%
YES	8	20%
Total	40	100.0%

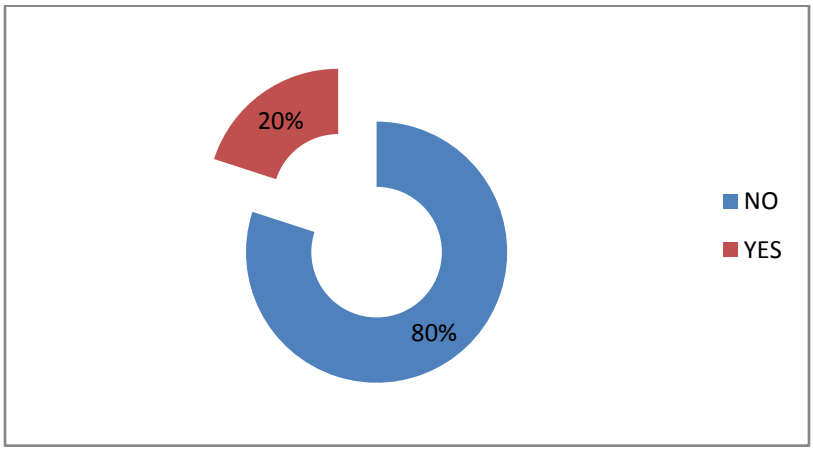


Figure 19: showing presence of pneumatosis intestinalis and porto-mesenteric pneumatosis

6.6 INVOLVEMENT OF MESENTERIC VESSELS

In our study, out of 40 patients who underwent MDCT scan, arterial thrombosis was seen in 20(50%) patients. 13(32.5%) patients were having venous thrombosis and 7(17.5%) were diagnosed as non-occlusive mesenteric ischemia (table 7g, Figure 20).

Table 7g: showing involvement of mesenteric vessels on CT scan

PATENCY OF MESENTERIC VESSELS	No. of cases	Percentage
ARTERIAL THROMBOSIS	20	50%
VENOUS THROMBOSIS	13	32.5%
NON-OCCLUSIVE MESENTERIC ISCHEMIA	7	17.5%
Total	40	100.0%

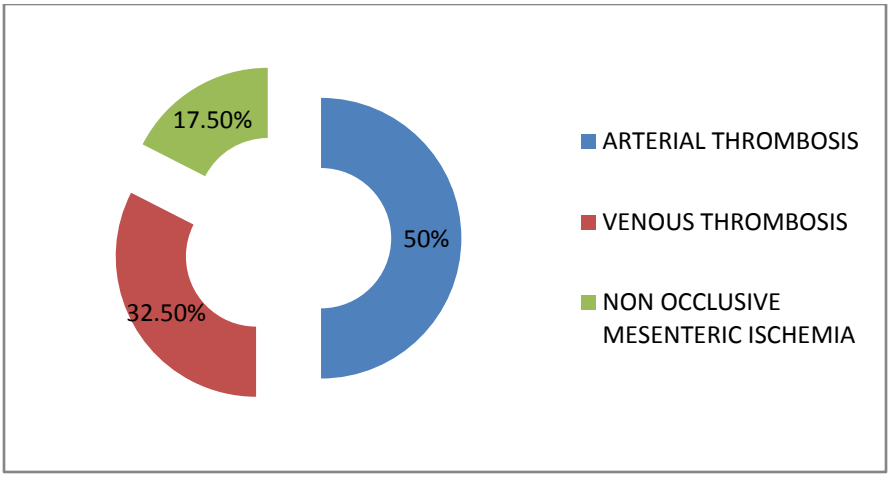


Figure 20: showing involvement of mesenteric vessels on CT scan

6.7 ASCITES

In 31(77.5%) out of 40 patients, free fluid was seen in peritoneal cavity. In 9 patients (22.5%) no free fluid was seen in peritoneal cavity (table 7h, Figure21)

Table 7h: CT findings of ascites

ASCITES	No. of cases	Percentage
NO	9	22.5%
YES	31	77.5%
Total	40	100.0%

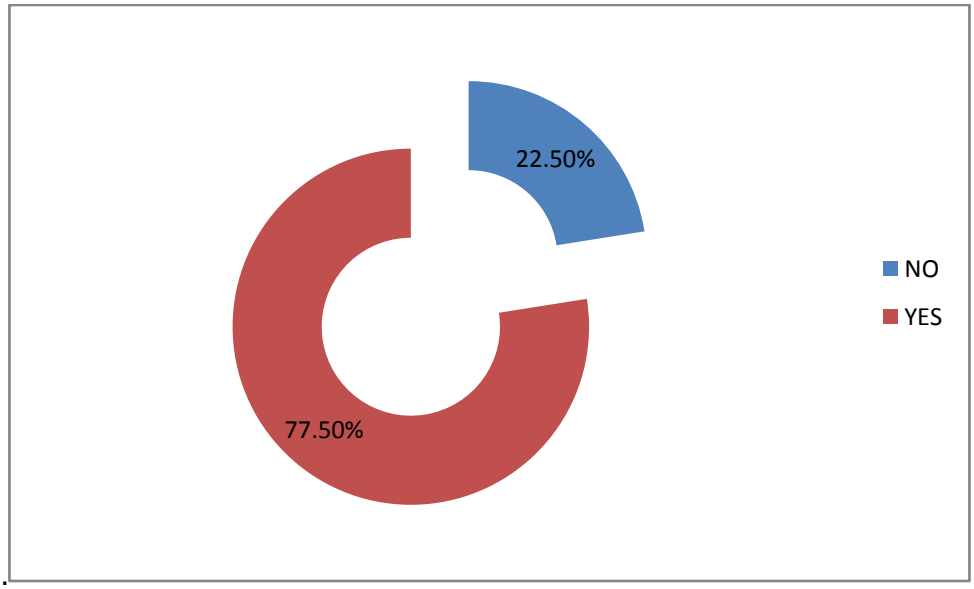


Figure 21: showing distribution of patients with ascites

6.8 SOLID ORGAN INFARCT ON IMAGING

Out of 40 patients, renal/splenic /liver infarcts were seen in 13 (32.5%) patients. There were no such findings in 27 (67.5%) patients (table 7i, Figure 22).

Table 7i: showing solid organ infarct on imaging

SOLID ORGAN INFARCT	No. of cases	Percentage
RENAL/SPLENIC/LIVER INFARCT	13	32.5%
NO	27	67.5%
Total	40	100.0%

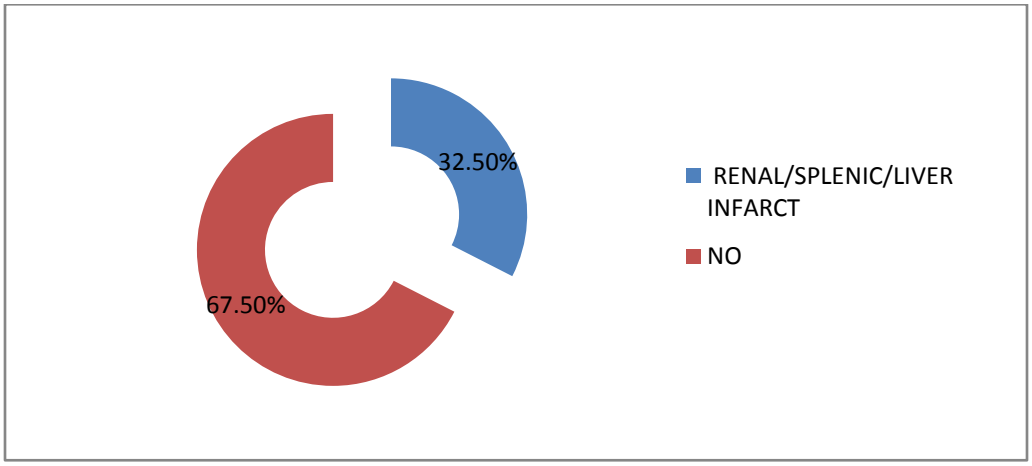


Figure 22: showing solid organ infarct

6.9. PNEUMOPERITONEUM

In our study, out of 40 patients, pneumoperitoneum was seen in 7(17.5%) patients. No CT features of pneumoperitoneum were seen in rest of 33 (82.5%) patients (table 7j,Figure 23)

Table 7j: showing presence of pneumoperitoneum on imaging

PNEUMOPERITONEUM	No. of cases	Percentage
NO	33	82.5%
YES	7	17.5%
Total	40	100.0%

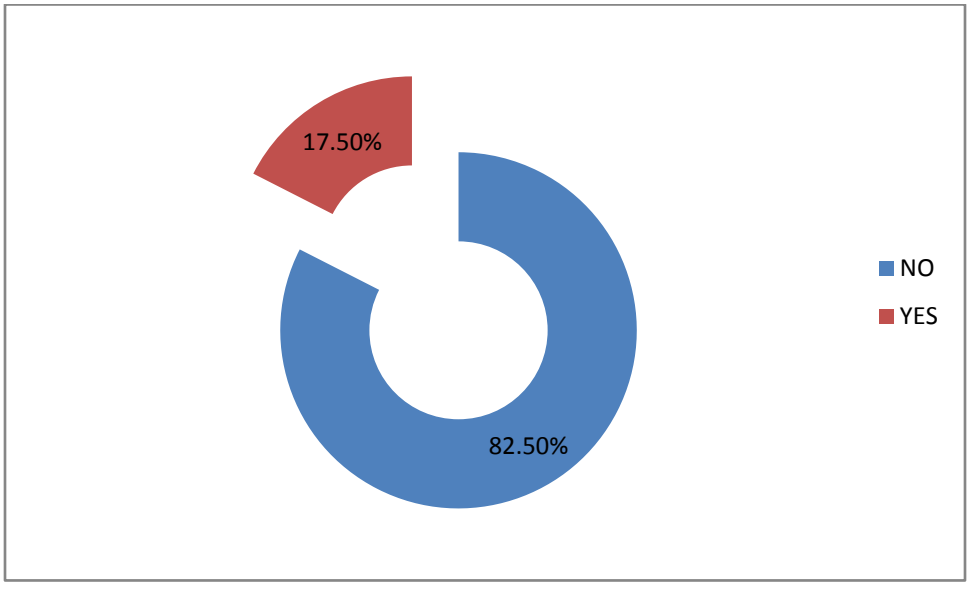


Figure 23- showing presence of pneumoperitoneum on imaging

7. CT DIAGNOSIS OF ACUTE MESENTERIC ISCHEMIA

Out of 40 patients who underwent CT scan, diagnosis of acute mesenteric ischemia was made in 39 patients (97.5%). In one patient, diagnosis of subacute intestinal obstruction was made in 1 (2.5%) patient (table 8, Figure 24).

Table 8: CT diagnosis of acute mesenteric ischemia on basis of imaging findings

CT DIAGNOSIS	No. of cases	Percentage
ACUTE MESENTERIC ISCHEMIA	39	97.5%
SMALL BOWEL OBSTRUCTION	1	2.5%
Total	40	100.0%

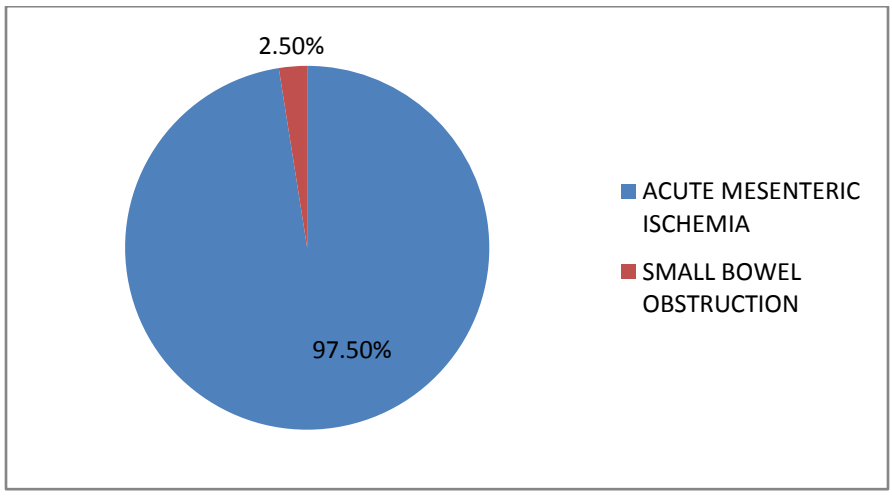


Figure 24: showing percentage of patients with diagnosis of acute mesenteric ischemia on imaging.

8. NUMBER OF PATIENTS WHO UNDERWENT SURGICAL /CLINICAL MANAGEMENT

Out of 40 patients, 27(67.5%) patients underwent surgery in which resection anastomosis of involved gut was done .Rest 13 patients (32.5%) were managed conservatively with heparin or antiplatelets (table 9, Figure 25).

Table 9: showing number of patients underwent surgical /clinical management

INTRAOPERATIVE FINDINGS/CLINICAL MANAGEMENT	No. of cases	Percentage
RESECTION	27	67.5%
CONSERVATIVE	13	32.5%
Total	40	100.0%

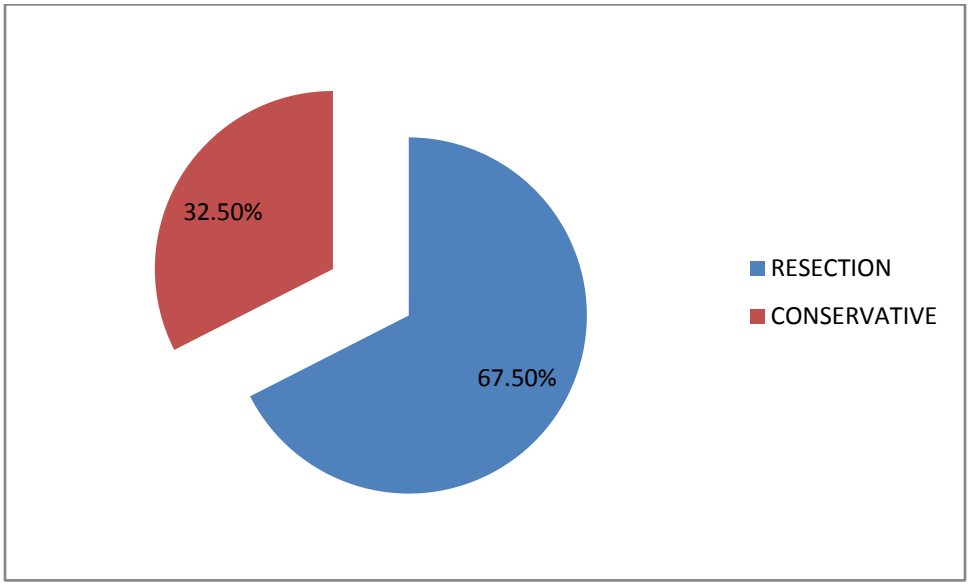


Figure 25: showing percentage of patients who underwent surgical/ clinical management

9. CORRELATION OF INTRA OPERATIVE AND CT FINDINGS

Out of all 27 patients who underwent surgery, condition and segment of involved gut loops per-operatively were correlating with CT findings in 26 (96.29%) patients. In 1(3.7%) patient, the condition and segment of involved gut loop was not correlating with CT findings (table 10 a, Figure 26).

Table 10a shows correlation of condition and segment of gut loops involved per-operatively with CT findings

CONDITION AND SEGMENT OF INVOLVED GUT LOOPS	No. of cases	Percentage
CORRELATING	26	96.29%
NOT CORRELATING	01	3.7%
Total	27	100.0%

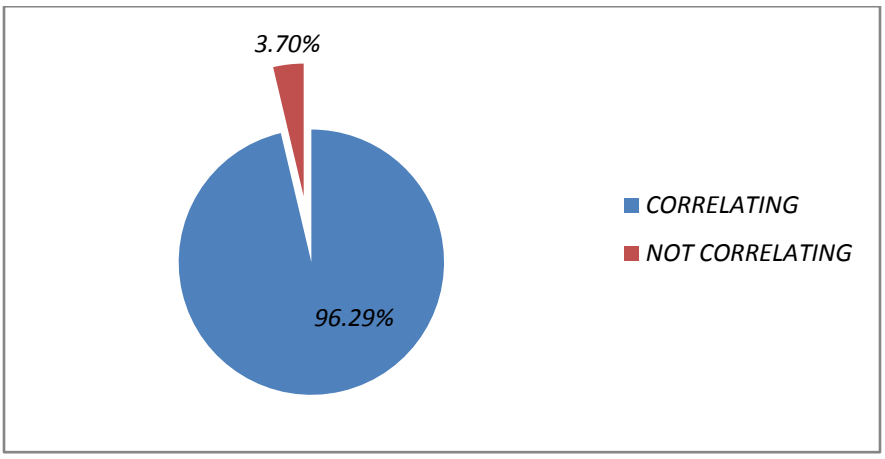


Figure 26: showing correlation of intra operative with CT findings

10. PRESENCE OF ANCILLARY INTRAOPERATIVE FINDINGS

Out of 27 patients who underwent surgery, adhesions were present in 4(14.8%) patients, closed loop was found in 1(3.7%) patient, strangulation was seen in 1 (3.7%) patient. 21 (77.7%) patients did not show such findings intraoperatively (table 10 b, Figure 27).

Table 10b: shows number of patients with intraoperative ancillary findings

Adhesion/ intususseption/ closed loop/ strangulation/ growth	No. of cases	Percentage
ADHESIONS	4	14.8%
CLOSED LOOP	1	3.7%
STRANGULATION	1	3.7%
NO	21	77.77%
Total	27	100%

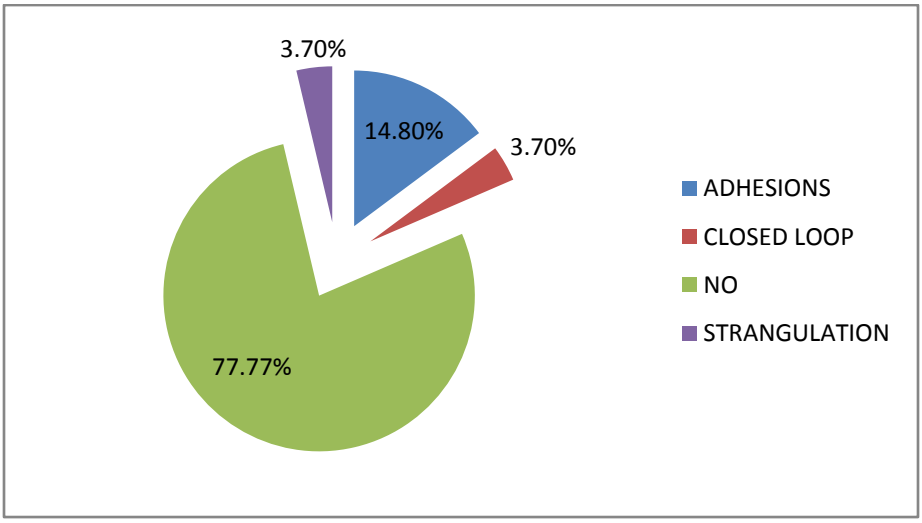


Figure 27: showing percentage of patients with ancillary findings intra operatively

11. CORRELATION OF CT FINDINGS WITH HISTOPATHOLOGICAL FINDINGS

Out of 27 patients who got operated, CT findings were correlating with histopathological findings in 26(96.29%) patients whereas there was no correlation in 1 (3.7%) patient (table 11, Figure 28)

Table 11: shows correlation of CT findings with histopathological findings

CORRELATION WITH HISTOPATHOLOGICAL DIAGNOSIS	No. of cases	Percentage
NO	1	3.7%
YES	26	96.29%
Total	27	100%

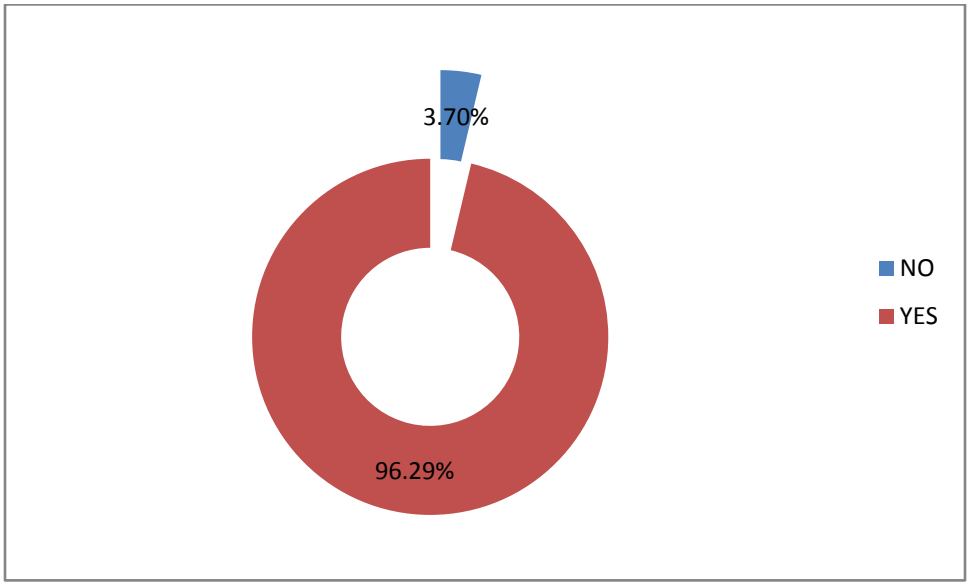


Figure 28: showing correlation of CT findings with histopathological findings

12. FOLLOW UP OF THE PATIENTS

Out of 40 patients, 34 (85%) patients were stable. 6 patients expired, out of which 3 were post operative and 3 were being managed conservatively (table 12, Figure 29).

Table 12: Follow up of the patients

FOLLOW UP	No. of cases	Percentage
EXPIRED AFTER SURGERY	3	7.5%
EXPIRED AFTER MEDICAL MANAGEMENT	3	7.5%
STABLE	34	85.0%
Total	40	100.0%

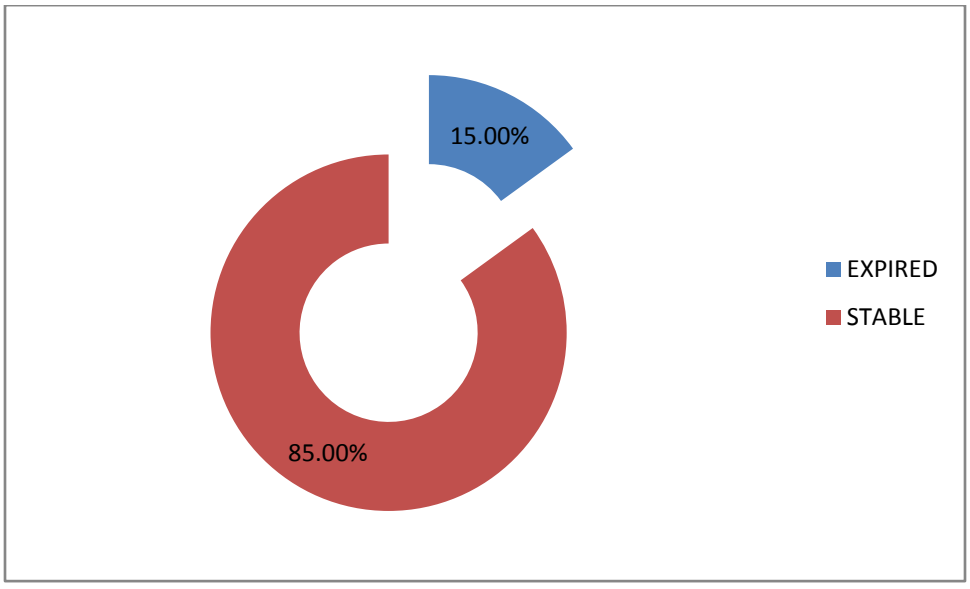


Figure 29: showing follow up of the patients

DISCUSSION

Acute mesenteric ischemia is one of the rare life-threatening conditions that accounts for approximately one in 1000 hospital admissions. Due to the absence of specific symptoms and laboratory data, it has high mortality rate of approximately 50-90%. Mesenteric ischemia is classified as either acute or chronic. The causes of acute mesenteric ischemia include arterial embolism, arterial thrombosis, venous thrombosis, and non-occlusive mesenteric ischemia, among which arterial causes are far more common than the venous causes.

The prognosis of acute mesenteric ischemia depends on the time to diagnosis and initiation of management. The mortality rate ranges from 0% to 10% with immediate management, increases to 50%–60% with a treatment delay of 6–12 hours, and increases further to 80%–100% with a delay of more than 24 hours after symptom onset. Therefore, early diagnosis and prompt management are mandatory in patients with acute mesenteric ischemia.

Since neither the symptoms of mesenteric ischemia nor the laboratory tests are specific for diagnosis, imaging plays an important role in the diagnosis of acute mesenteric ischemia.

Contrast enhanced multidetector computed tomography (CT) is most sensitive and specific for the diagnosis of AMI so it should be the first-line imaging modality. MDCT can differentiate AMI from other causes of acute abdomen and can depict mesenteric ischemia, its underlying causes, and its severity.

This study reports the role of MDCT in the diagnosis of acute mesenteric ischemia and its correlation with clinico-surgical outcome. This study aims

at assessing the efficacy of Multi-Detector Computed Tomography (MDCT) in the diagnosis of acute mesenteric ischemia.

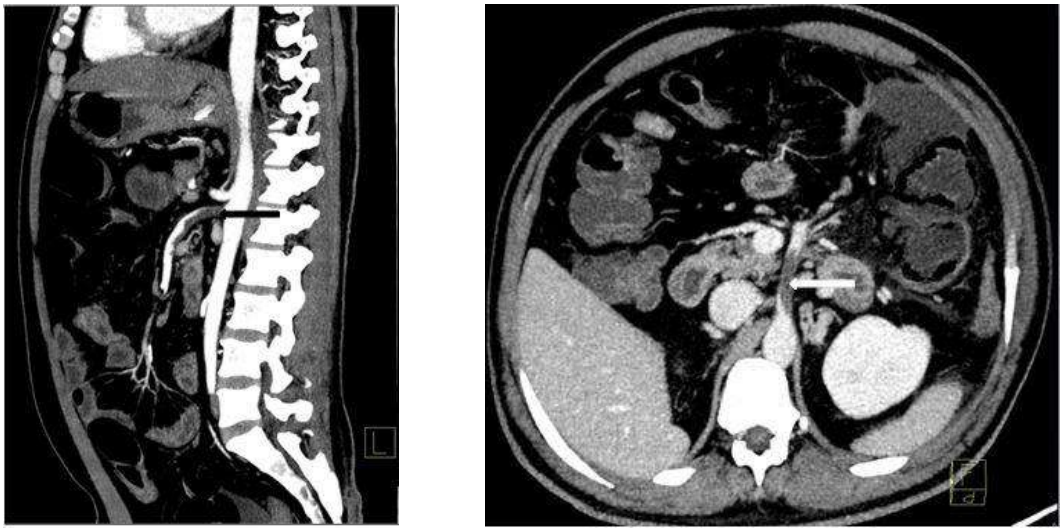
Out of 40 patients who underwent CT scan, clinical diagnosis of acute mesenteric ischemia prior to CT scan was made only in 32.5% patients whereas majority of the patients (35%) were diagnosed with subacute intestinal obstruction. Rest were diagnosed with other alternative diagnosis. In our study the incidence of the disease was highest in age group between 41-50 years with mean age of 56.6 years, with male to female ratio of 1.3:1. It is in close approximation with the study done by Haghighi PH et al. in which mean age of development of acute mesenteric ischemia was 57 years [2]. Majority of the patients (95%) in our study presented with abdominal pain, 50 % presented with abdominal distension, 50% with vomiting. These findings are in close approximation with study done by Ahlan E et al in which 90.6% patient had pain abdomen, 48.5% presented with vomiting and 26.1% presented with abdominal distension [67].

Although findings of an elevation of WBC's count (> 11000) in our study were present in 60% of patients, these findings are nonspecific and are not helpful in diagnosing mesenteric ischemia. Moreover waiting for laboratory results should not delay radiographic studies if serious suspicion of mesenteric ischemia exists.

Approximately 2/3rd of the patients in this study had one or more predisposing factors responsible for acute mesenteric ischemia such as hypertension, atrial fibrillation, carcinoma, chronic liver disease. Out of these, 52.5% patients were hypertensive.

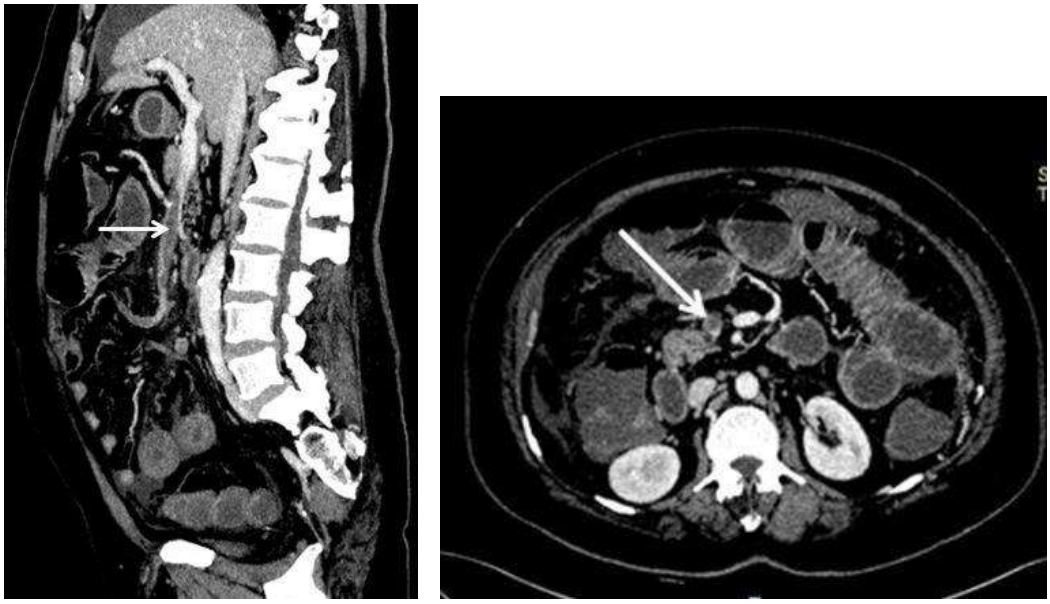
In our study, acute mesenteric ischemia due to arterial causes was most common cause, seen in 50% patients. Second most common cause was venous thrombosis (32.5%) followed by non occlusive mesenteric ischemia (17.5%). These findings are in close agreement to a study done

CASES



(a) **(b)**

Figure: Contrast enhanced saggital (a) and axial (b) CT scan shows hypoattenuating thrombus in SMA [black arrow in (a), white arrow in (b)]



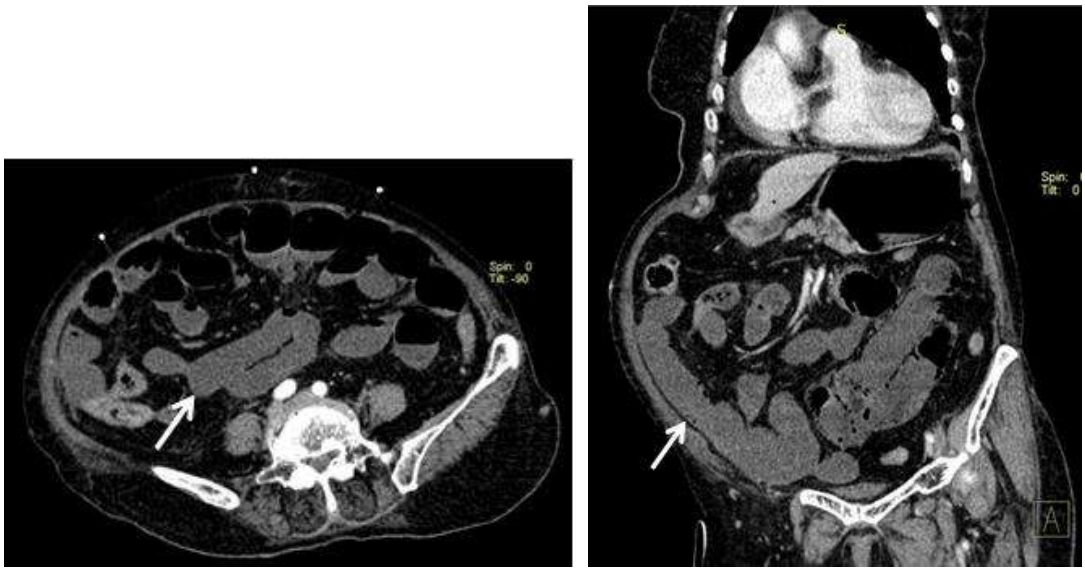
(a) **(b)**

Figure: Contrast enhanced saggital (a) and axial (b) CT shows hypodense thrombus in SMV (arrows)

(a) **(b)**

Figure: Non contrast axial (a) and coronal (b) CT scan shows hyperattenuating walls of small bowel in right hemi abdomen (arrows)

Figure: Contrast enhanced coronal CT scan shows diffuse wall thickening in the ileum (white arrow) with ascitis (yellow arrow) and mesenteric fat stranding (☆)



(a) **(b)**

Figure: Contrast enhanced axial (a) and coronal (b) CT shows non enhancing and papery thin walls in the ileum (arrows).

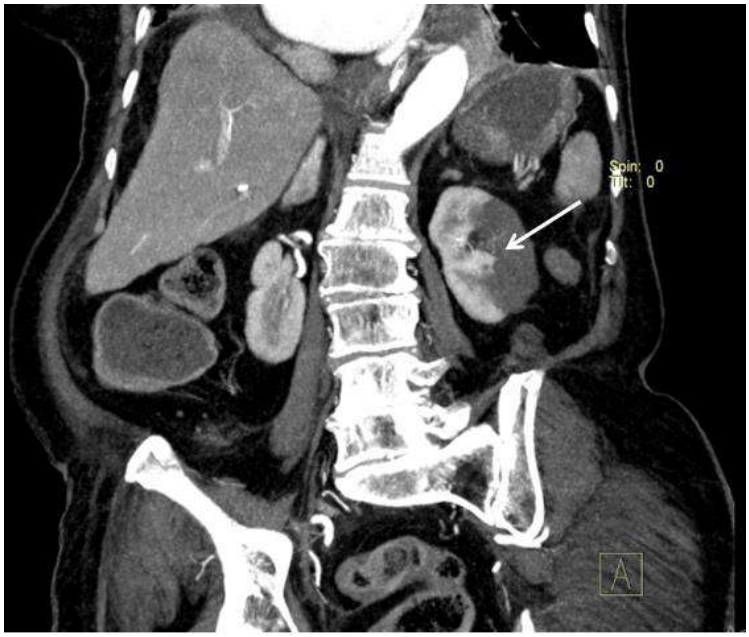
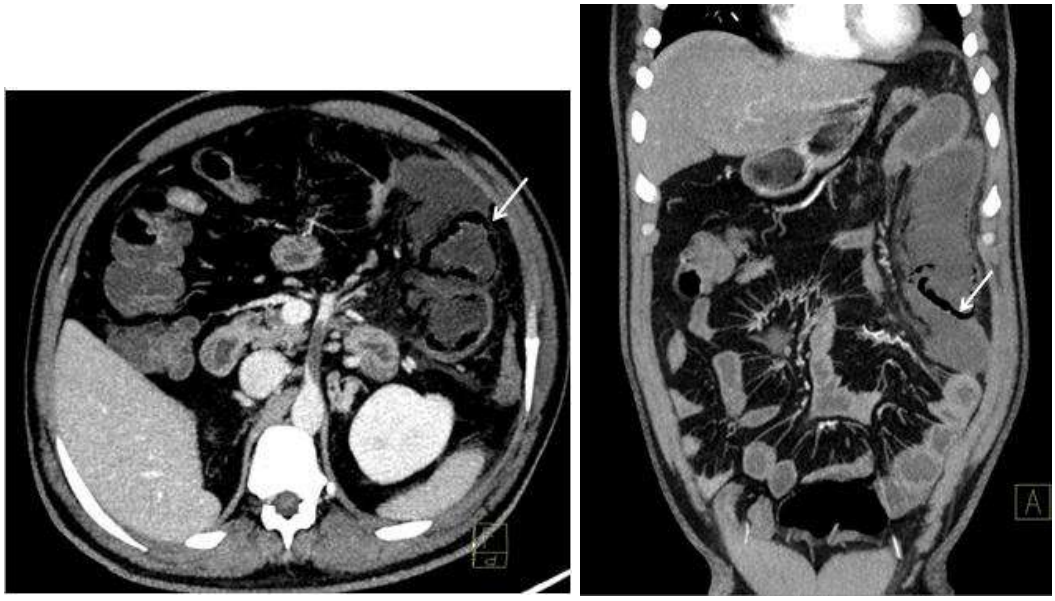


Figure: Renal infarct in a patient of acute mesenteric ischemia . Contrast enhanced CT shows wedge shaped non enhancing infarct in left kidney (arrow).



(a) **(b)**

Figure: Contrast enhanced axial (a) and coronal (b) CT showing gas within the bowel wall which is nonenhancing and dilated(arrows)

KEY TO MASTERCHART

S.NO.	SERIAL NUMBER
M	MALE
F	FEMALE
TLC	TOTAL LEUKOCYTE COUNT
CT	COMPUTED TOMOGRAPHY
CLD	CHRONIC LIVER DISEASE
SLE	SYSTEMIC LUPUS ERYTHEMATOSUS
CA	CARCINOMA
SMV	SUPERIOR MESENTERIC VEIN
SMA	SUPERIOR MESENTERICARTERY

S. NO.	MRD NO.	NAME	AGE	GENDER	CHIEF COMPLAINTS					CLINICAL DIAGNOSIS	TLC	SERUM LACTATE	CO MORBIDITY	BOWEL WALL THICKENING/THINNING		WALL ATTENUATION ON NON CONTRAST CT	ENHANCEMENT OF BOWEL WALL ON POST CONTRAST CT	BOWEL WALL DILATATION	CHANGES IN MESENTRY	PNEUMATOSIS INTESTINALIS	VENOUS THROMBUS
					PAIN ABDOMEN	CONSTIPATION/ OBSTIPATION	VOMITING	ABDOMINAL DISTENSION	BLOOD IN STOOLS					THICKENING	THINNING				STRANDING		
1	604894	SK	80	F	YES	YES	YES	NO	NO	ACUTE MESENTERIC ISCHEMIA	19.3	4.9	HYPERTENSION	NO	YES	NORMAL	NON ENHANCING WALLS	YES	YES	NO	NO
2	595966	JK	75	F	YES	YES	NO	YES	NO	ACUTE MESENTERIC ISCHEMIA	13.2	_	ATRIAL FIBRILLATION	YES	NO	HYPERATTENUATING	NORMAL	YES	YES	NO	NO
3	667929	NM	34	F	YES	YES	YES	YES	NO	INTESTINAL PERFORATION	3.4	_	NO	YES	NO	HYPERATTENUATING	HYPOENHANCING	NO	YES	YES	NO
4	664313	OM	35	M	YES	NO	NO	YES	NO	ACUTE MESENTERIC ISCHEMIA	5.3	_	NO	YES	NO	HYPERATTENUATING	HYPOENHANCING	NO	YES	NO	NO
5	666737	DI	28	M	YES	YES	YES	YES	NO	ACUTE MESENTERIC ISCHEMIA	6.6	_	NO	NO	NO	NORMAL	NORMAL	YES	YES	NO	SMV THROMBOSIS
6	759670	AL	63	M	YES	YES	YES	YES	NO	ACUTE GASTRITIS	7.9	1.5	HYPERTENSION	NO	NO	NORMAL	NON ENHANCING	YES	YES	NO	NO
7	753586	SR	42	M	YES	YES	YES	NO	NO	ACUTE GASTRITIS	12.6	_	HYPERTENSION	YES	NO	NORMAL	NON ENHANCING	NO	YES	NO	SMV THROMBOSIS
8	231958	BS	60	M	YES	YES	NO	YES	NO	ACUTE PANCREATITIS	28	2.9	HYPERTENSION	NO	NO	NORMAL	NON ENHANCING	YES	YES	NO	NO
9	837222	MS	67	M	YES	YES	YES	YES	YES	CHRONIC LIVER DISEASE	3.2	_	CLD	YES	NO	NORMAL	HYPOENHANCING	YES	YES	NO	SMV THROMBOSIS
10	491870	NI	42	F	YES	NO	YES	NO	NO	ACUTE GASTRITIS	3.4	_	CA CERVIX	YES	NO	NORMAL	NON ENHANCING	NO	YES	NO	NO
11	205332	GK	82	F	YES	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	11.8	_	HYPERTENSION	YES	NO	NORMAL	NORMAL	YES	YES	NO	NO
12	775108	MR	86	M	YES	NO	YES	YES	NO	SUBACUTE INTESTINAL OBSTRUCTION	12.6	1.7	NO	NO	NO	NORMAL	HYPOENHANCING	YES	YES	NO	NO
13	717547	SL	66	M	YES	YES	NO	YES	NO	ACUTE MESENTERIC ISCHEMIA	16.9	2.1	HYPERTENSION	YES	NO	NORMAL	HYPOENHANCING	YES	YES	NO	SMV THROMBOSIS
14	733122	HS	36	M	YES	YES	NO	YES	NO	ACUTE PANCREATITIS	8.9	_	NO	NO	YES	NORMAL	NON ENHANCING	YES	YES	YES	NO
15	38966	DK	47	F	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	19.5	2.1	HYPERTENSION	YES	NO	NORMAL	HYPOENHANCING	YES	YES	YES	NO
16	785275	SK	45	F	YES	YES	YES	YES	NO	SUBACUTE INTESTINAL OBSTRUCTION	13.4	_	NO	NO	NO	NORMAL	HYPOENHANCING	YES	NO	NO	NO
17	642200	KL	72	M	YES	NO	NO	NO	NO	INGUINAL HERNIA	8.9	_	HYPERTENSION	NO	NO	NORMAL	HYPOENHANCING	YES	YES	NO	SMV THROMBOSIS
18	735979	SS	66	M	YES	YES	NO	YES	NO	SUBACUTE INTESTINAL OBSTRUCTION	11.4	_	NO	YES	NO	NORMAL	NON ENHANCING	YES	YES	NO	SMV THROMBOSIS
19	660141	BS	55	M	YES	YES	YES	YES	NO	SUBACUTE INTESTINAL OBSTRUCTION	9	1.3	NO	NO	NO	HYPERATTENUATING	NON ENHANCING	YES	YES	YES	NO
20	784511	MS	56	M	YES	NO	YES	YES	NO	SUBACUTE INTESTINAL OBSTRUCTION	7.6	_	HYPERTENSION	YES	NO	NORMAL	HYPOENHANCING	YES	YES	NO	NO
21	734475	SK	65	F	YES	YES	YES	YES	NO	SUBACUTE INTESTINAL OBSTRUCTION	28.6	_	HYPERTENSION	NO	YES	NORMAL	HYPERENHANCING	NO	YES	NO	NO
22	589736	LS	40	M	YES	YES	YES	YES	no	SUB ACUTE INTESTINAL OBSTRUCTION	12	0.9	NO	YES	NO	NORMAL	NORMAL	YES	YES	NO	NO
23	735109	SK	65	F	YES	YES	YES	NO	NO	ACUTE ADOMEN	19.9	_	HYPERTENSION	NO	YES	NORMAL	HYPER ENHANCING	YES	YES	NO	NO
24	836836	HS	29	M	YES	NO	NO	NO	NO	ACUTE ABDOMEN	15.9	0.9	NO	NO	NO	HYPERATTENUATING	NORMAL	NO	YES	NO	NO
25	884692	KS	93	M	YES	NO	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	12.6	3.2	HYPERTENSION	YES	NO	NORMAL	HYPOENHANCING	NO	NO	NO	NO
26	884450	PG	43	F	YES	NO	NO	NO	NO	ACUTE MESENTRIC ISCHEMIA	13.5	7	SLE	YES	NO	HYPERATTENUATING	NON ENHANCING	NO	YES	NO	SMV THROMBOSIS
27	899898	PK	58	M	NO	NO	YES	NO	YES	ACUTE MESENTERIC ISCHEMIA	14.4	4.1	HYPERTENSION	YES	NO	NORMAL	NORMAL	NO	YES	NO	NO
28	880076	JS	60	M	YES	YES	NO	NO	NO	ACUTE PANCREATITIS	9.7	_	HYPERTENSION	YES	NO	HYPERATTENUATING	HYPOENHANCING	YES	YES	NO	NO
29	664519	VK	49	M	YES	NO	NO	YES	NO	ACUTE MESENTERIC ISCHEMIA	14.3	1.5	DEEP VEIN THROMBOSIS	YES	NO	NORMAL	NORMAL	NO	YES	NO	SMV THROMBOSIS

S. NO.	MRD NO.	PATENCY OF MESENTRIC VESSELS ARTERIAL THROMBUS	NON OCCLUSIVE MESENTERIC ISCHEMIA	ABDOMINAL FLUID COLLECTION	FREE FLUID IN PERITONEAL CAVITY	INVOLVEMENT OF OTHER ORGANS	PORTOMESENTERIC PNEUMATOSIS	PNEUMOPERITONEUM	CT DIAGNOSIS	INTRAOPERATIVE FINDINGS/CLINICAL MANAGEMENT SURGICAL/ CONSERVATIVE MANAGEMENT	CONDITION OF GUT LOOP	CORRELATION OF INVOLVED GUT LOOPSWITH CT FINDING	ADHESION/ CLOSED LOOP/ INTUSUSSEPTION/ STRANGULATION	CORRELATING WITH HISTOPATHOLOGICAL DIAGNOSIS	FOLLOW UP
1	604894	SMA THROMBOSIS	NO	NO	YES	RENAL INFARCT	YES	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
2	595966	SMA THROMBOSIS	YES	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	CONSERVATIVE	_	_	NO	_	STABLE
3	667929	NO	YES	NO	YES	SPLENIC INFARCT	NO	YES	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
4	664313	NO	YES	NO	YES	NO	NO	YES	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
5	666737	NO	NO	NO	NO	NO	NO	YES	SMALL BOWEL OBSTRUCTION	RESECTION	GANGRENOUS	NO	ADHESIONS	NO	STABLE
6	759670	SMA THROMBOSIS	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
7	753586	NO	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
8	231958	SMA THROMBOSIS	NO	NO	NO	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	CONSERVATIVE	_	_	NO	_	STABLE
9	837222	NO	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	EXPIRED
10	491870	NO	YES	YES	YES	RENAL INFARCT	NO	YES	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	EXPIRED
11	205332	NO	YES	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
12	775108	SMA THROMBOSIS	NO	NO	NO	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
13	717547	NO	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
14	733122	SMA THROMBOSIS	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
15	38966	SMA THROMBOSIS	NO	NO	YES	RENAL INFARCT SPLENIC INFARCT	NO	NO	ACUTE MESENTERIC ISCHEMIA	CONSERVATIVE	_	_	NO	_	EXPIRED
16	785275	SMA THROMBOSIS	NO	NO	YES	LIVER INFARCT SPLENIC INFARCT RENAL INFARCT	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	EXPIRED
17	642200	SMA THROMBOSIS	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	STRANGULATION	yes	STABLE
18	735979	NO	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	CONSERVATIVE	__	_	NO	_	STABLE
19	660141	SMA THROMBOSIS	NO	NO	YES	SPLENIC INFARCT	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
20	784511	NO	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	ADHESIONS	YES	STABLE
21	734475	SMA THROMBOSIS	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA.	CONSERVATIVE	_	_	NO	_	STABLE
22	589736	SMA THROMBOSIS	NO	NO	YES	SPLENIC INFARCT	NO	NO	ACUTE MESENTERIC ISCHEMIA	CONSERVATIVE	_	_	NO	_	STABLE
23	735109	SMA THROMBOSIS	NO	NO	NO	RENAL INFARCT	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
24	836836	NO	YES	YES	YES	SPLENIC INFARCT	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
25	884692	SMA THROMBOSIS	NO	NO	NO	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	CONSERVATIVE	_	_	NO	_	STABLE
26	884450	NO	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	CONSERVATIVE	_	_	NO	_	EXPIRED
27	899898	SMA THROMBOSIS	NO	NO	NO	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	CONSERVATIVE	_	_	NO	_	STABLE
28	880076	SMA THROMBOSIS	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	ADHESIONS	YES	STABLE
29	664519	NO	NO	NO	NO	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	CONSERVATIVE	_	_	NO	_	STABLE

S. NO.	MRD NO.	NAME	AGE	GENDER	CHIEF COMPLAINTS					CLINICAL DIAGNOSIS	TLC	SERUM LACTATE	CO MORBIDITY	BOWEL WALL THICKENING/THINNING		WALL ATTENUATION ON NON CONTRAST CT	ENHANCEMENT OF BOWEL WALL ON POST CONTRAST CT	BOWEL WALL DILATATION	CHANGES IN MESENTRY	PNEUMATOSIS INTESTINALIS	VENOUS THROMBUS
					PAIN ABDOMEN	CONSTIPATION/ OBSTIPATION	VOMITING	ABDOMINAL DISTENSION	BLOOD IN STOOLS					THICKENING	THINNING				STRANDING		
30	796056	SU	38	F	YES	NO	NO	NO	NO	SUBACUTE INTESTINAL OBSTRUCTION	13.9	1.5	NO	YES	NO	NORMAL	NORMAL	YES	YES	NO	SMV THROMBOSIS
31	53842	PB	48	M	YES	YES	YES	YES	YES	ACUTE MESENTERIC ISCHEMIA	19.9	6.7	CLD	YES	NO	HYPERATTENUATING	NONENHANCING	YES	YES	NO	SMV THROMBOSIS
32	880120	HB	50	F	YES	YES	YES	NO	NO	SUBACUTE INTESTINAL OBSTRUCTION	13.4	_	HYPERTENSION	NO	NO	NORMAL	HYPOENHANCING	YES	YES	NO	NO
33	75862	SO	56	F	YES	YES	NO	NO	NO	ACUTE COLITIS	20.8	_	HYPERTENSION	YES	NO	NORMAL	NORMAL	NO	YES	NO	NO
34	865721	VI	65	F	YES	YES	NO	YES	NO	ACUTE MESENTRIC ISCHEMIA	12	2.3	HYPERTENSION	NO	YES	NORMAL	NONENHANCING	YES	YES	YES	NO
35	874618	KK	81	M	YES	NO	NO	NO	NO	SUBACUTE INTESTINAL OBSTRUCTION	7.8	_	HYPERTENSION	YES	NO	NORMAL	HYPERENHANCING	YES	YES	NO	NO
36	145421	SA	35	F	YES	NO	NO	NO	NO	SUBACUTE INTESTINAL OBSTRUCTION	8.8	_	HYPERTENSION	NO	YES	NORMAL	NONENHANCING	YES	YES	NO	NO
37	628120	DK	86	F	YES	YES	NO	NO	NO	SUBACUTE INTESTINAL OBSTRUCTION	29	_	HYPERTENSION	YES	YES	NORMAL	NONENHANCING	YES	YES	YES	NO
38	879491	JK	85	F	YES	YES	YES	YES	NO	SUBACUTE INTESTINAL OBSTRUCTION	5.4	_	HYPERTENSION	YES	NO	NORMAL	HYPOENHANCING	YES	YES	YES	SMV THROMBOSIS
39	946238	PU	32	M	YES	NO	YES	NO	NO	ACUTE PANCREATITIS	20	_	NO	YES	NO	NORMAL	HYPOENHANCING	YES	YES	NO	SMV THROMBOSIS
40	641824	PR	49	M	YES	YES	YES	NO	NO	SUBACUTE INTESTINAL OBSTRUCTION	7	_	NO	YES	NO	NORMAL	NORMAL	NO	YES	NO	SMV THROMBOSIS

S. NO.	MRD NO.	PATENCY OF MESENTRIC VESSELS ARTERIAL THROMBUS	NON OCCLUSIVE MESENTERIC ISCHEMIA	ABDOMINAL FLUID COLLECTION	FREE FLUID IN PERITONEAL CAVITY	INVOLVEMENT OF OTHER ORGANS	PORTOMESENTERIC PNEUMATOSIS	PNEUMOPERITONEUM	CT DIAGNOSIS	INTRAOPERATIVE FINDINGS/CLINICAL MANAGEMENT SURGICAL/ CONSERVATIVE MANAGEMENT	 CONDITION OF GUT LOOP	 CORRELATION OF INVOLVED GUT LOOPSWITH CT FINDING	 ADHESION/ CLOSED LOOP/ INTUSUSSEPTION/ STRANGULATION	CORRELATING WITH HISTOPATHOLOGICAL DIAGNOSIS	FOLLOW UP
30	796056	NO	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
31	53842	NO	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
32	880120	SMA THROMBOSIS	NO	NO	YES	RENAL INFARCT	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	EXPIRED
33	75862	SMA THROMBOSIS	NO	NO	NO	RENAL INFARCT	NO	NO	ACUTE MESENTERIC ISCHEMIA	CONSERVATIVE	_	_	NO	_	STABLE
34	865721	SMA THROMBOSIS	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
35	874618	NO	YES	NO	YES	NO	NO	YES	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	CLOSED LOOP	YES	STABLE
36	145421	SMA THROMBOSIS	NO	YES	YES	RENAL INFARCT SPLENIC INFARCT	NO	NO	ACUTE MESENTERIC ISCHEMIA	CONSERVATIVE	_	_	NO	_	STABLE
37	628120	SMA THROMBOSIS	NO	NO	YES	RENAL INFARCT	NO	YES	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
38	879491	NO	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	ADHESIONS	YES	STABLE
39	946238	NO	NO	NO	YES	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	RESECTION	GANGRENOUS	YES	NO	YES	STABLE
40	641824	NO	NO	NO	NO	NO	NO	NO	ACUTE MESENTERIC ISCHEMIA	CONSERVATIVE	_	YES	NO	_	STABLE

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The Principal,
DMC, Ludhiana.

Subject: **Approval of Plan of Thesis.**

This is to inform you that the Faculty of Medical Sciences in its meeting held on 29.05.2019 has approved the plan of thesis of **Narinder Salhotra**, a student of your college for **MD Radio-Diagnosis** along with the names of Supervisor/Co-Supervisor as under:-

Topic Plan of Thesis

Role of mdct in patients of acute mesenteric ischemia and correlation with clinico-surgical outcome

Supervisor
Dr. Ritu Dhawan Galhotra
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Co-Supervisor
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The student has to submit the four copies of thesis (along with PDF format) , to the Controller of Examinations, BFUHS, Faridkot, at least six months before the commencement of theory examination, if he/she is otherwise eligible to take the examination. He /She must directed to attach a photocopy of this letter with the forwarding letter while submitting thesis to the University along with the letter of approval of University for change of supervisor/Co-Supervisor, change of topic,(if any).

S P Singh

Dr. S P Singh MS(Oph)
Controller of Examinations

AC R

Note :

89. *If any discrepancy found regarding topic of thesis or Supervisor/Co-Supervisor, inform undersigned within one month after issue of this letter.*
90. *The student may submit the thesis as per the schedule already conveyed i.e for May/June examination 30th Nov of the preceding the year of examination and for Nov/Dec examinations 31st May of the year of examination.*

ROLE OF MDCT IN PATIENTS OF ACUTE MESENTERIC ISCHEMIA AND CORRELATION WITH CLINICO-SURGICAL OUTCOME

THESIS PROPOSAL

FOR APPROVAL OF SUBJECT OF THESIS TO BE SUBMITTED IN

PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MD

In

RADIODIAGNOSIS

OF THE

BABA FARID UNIVERSITY OF HEALTH SCIENCES

FARIDKOT

November, 2018

Dr. Narinder Salhotra

DEPARTMENT OF RADIODIAGNOSIS
DAYANAND MEDICAL COLLEGE AND HOSPITAL
LUDHIANA

ABSTRACT OF PLAN OF THESIS

Title	ROLE OF MDCT IN PATIENTS OF ACUTE MESENTERIC ISCHEMIA AND CORRELATION WITH CLINICO-SURGICAL OUTCOME
For the degree of	MD (Radiodiagnosis)
Name of the candidate	Dr. Narinder Salhotra
Supervisor	Dr. Ritu Dhawan Galhotra, Associate Professor, Department of Radiodiagnosis, DMCH, Ludhiana
Co-supervisor(s)	Dr. Chandan Kakkar, Assistant Professor, Department of Radiodiagnosis, DMCH, Ludhiana Dr. Amandeep Singh Nar, Associate Professor, Department of Surgery, DMCH, Ludhiana.
Institution	Dayanand Medical College and Hospital, Ludhiana
University	Baba Farid University of Health Sciences, Faridkot

Introduction: Acute mesenteric ischemia is an abdominal emergency occurring in nearly 1% of patients presenting with acute abdomen. Sixth and seventh decade of life and background of atrial fibrillation are the risk factors. Early diagnosis is very important for the improved survival of the patient. Acute mesenteric ischemia frequently presents with non specific features such as vomiting, loose stools and abdominal distension. The classical triad of fever, hematochezia and abdominal pain is seen in only 30% of the patients so it is difficult to diagnose clinically .MDCT is gold standard and first line test to diagnose intestinal ischemia.

Aim of Study: 1. To assess the efficacy of Multi-Detector Computed Tomography (MDCT) Abdomen in the diagnosis of acute mesenteric ischemia. 2. To correlate it with surgical and/or clinical outcome.

Materials & Methods: This study will be conducted over a period of one and half year from 1st November 2018 to 31st May 2020 on patients with clinical suspicion of acute mesenteric ischemia referred for MDCT Abdomen to the Department of Radio-diagnosis, Dayanand Medical College & Hospital, Ludhiana.

Clinical Significance: To diagnose the acute mesenteric ischemia in its early stage and to reduce the overall mortality rate and improve the prognosis and overall clinical outcome.

Keywords: Acute mesenteric ischemia, MDCT, bowel wall thickening.

(Signature)	(Signature)	(Signature)	(Signature)	(Signature)
Candidate	Co-supervisor	Co-supervisor	Supervisor	Principal

CERTIFICATE OF FACILITIES AVAILABLE

This is to certify that the facilities for work on the subject of thesis titled **"ROLE OF MDCT IN PATIENTS OF ACUTE MESENTERIC ISCHEMIA AND CORRELATION WITH CLINICO-SURGICAL OUTCOME"** exist in the Department of Radiodiagnosis, DMC&H, Ludhiana and will be provided to the candidate. We will see that the data being included in the thesis is genuine and is collected by the candidate herself under our supervision and guidance.

Supervisor

Dr. Ritu Dhawan Galhotra
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Place : DMCH Ludhiana

Date : 27/12/18

APPROVAL PROFORMA
BY
RESEARCH & ETHICAL COMMITTEE
DAYANAND MEDICAL COLLEGE & HOSPITAL, LUDHIANA

Name of candidate	Dr. Narinder Salhotra
Department	Radiodiagnosis
Topic of Thesis	Role of MDCT in patients of acute mesenteric ischemia and correlation with clinico surgical outcome
Likely date of appearing in PG examination	June 2021
Date of enrollment	10th May, 2018
Name of Head of Department	Dr. Kavita Saggar
1) Supervisor **2) Co-Supervisor(s)**	Dr. Ritu Dhawan Galhotra Dr. Chandan Kakkar Dr. Amandeep Singh Nar
Signature of Members of Research Committee with Stamp	**Signature of Members of Ethics Committee with Stamp**
1. HOD Pharmacology	1. HOD Physiology
2. HOD Surgery	2. HOD Pathology
3. HOD Pathology	3. HOD Pharmacology
4. HOD Medicine	4. HOD SPM
5. Dean Academics	5. HOD Medicine
6. Vice Principal	6. HOD Surgery
	7. HOD Obst. & Gynae.
	8. Legal Expert
	9. Secretary, IEC
	10. Dean Academics
	11. Vice Principal
	12. Principal

Approved: Yes / No

Chairperson
Research Committee

Chairperson
Research Committee

Approved: Yes / No

Chairperson
Ethics Committee

Chairperson
Ethics Committee

BABA FARID UNIVERSITY OF HEALTH SCIENCES, FARIDKOT

PROFORMA FOR REGISTRATION OF SUBJECT FOR DISSERTATION

1	NAME OF THE CANDIDATE AND ADDRESS	DR. NARINDER SALHOTRA MAIN ROAD,WARD NO.4 MOHALLA FATEH CHAK TARN TARAN
2	NAME OF THE INSTITUTE	DAYANAND MEDICAL COLLEGE AND HOSPITAL, LUDHIANA
3	COURSE OF STUDY AND SUBJECT	M.D RADIODIAGNOSIS
4	DATE OF ADMISSION OF COURSE	10th May 2018
5	TITLE OF THE TOPIC	ROLE OF MDCT IN PATIENTS OF ACUTE MESENTERIC ISCHEMIA AND CORRELATION WITH CLINICO SURGICAL OUTCOME

6. BRIEF RESUME OF THE INTENDED WORK

6.1 NEED FOR THE STUDY

Acute mesenteric ischemia is a life threatening surgical emergency occurring when blood flow to the bowel loops decreases because of mesenteric arterial hypoperfusion, impaired venous drainage or occlusion. It is estimated that nearly 1% of patients presenting with acute abdomen have ischemic intestinal disease involving the small bowel or colon. Acute mesenteric ischemia requires quick and prompt diagnosis and therapeutic care. The incidence of this disease is rising gradually due to various reasons such as aging of population, ability of intensive care units to salvage critically sick patients, and increased clinical awareness of this disorder.

Without treatment, acute mesenteric ischemia may progress to mesenteric infarction whose prognosis remains grim.

Bowel ischemia is considered a potentially transient and reversible event; however, it may lead to intestinal infarction that requires surgical or interventional management. For this reason, early diagnosis is important to improve survival rates. In case of late or missed cases, mortality rates from intestinal ischemia are very high ranging from 60 to 90 %.

The increased spatial and temporal resolution, high-quality multi-planar reconstructions, maximum intensity projections, vessel probe, surface-shaded volume rending and tissue transition projections makes MDCT whole abdomen as the gold standard and first line investigation for the diagnosis of acute mesenteric ischemia with reported sensitivity of 60 to 95%, specificity of

92 to 100%, positive predictive value of 90 to 100% and negative predictive value of 94 to 98%. MDCT contributes to appropriate treatment planning and provides important prognostic information about the nature and extent of the disease.it can be performed quickly in critically ill patients and is less dependent on patient's factors as compared to other imaging techniques. Unenhanced CT is reportedly required for the diagnosis of intestinal ischemia in order to evaluate submucosal hemorrhage, hyperdense/calcified thrombi and atherosclerotic plaque and to obtain a baseline attenuation measurement of the bowel wall for the assessment of the enhancement. The arterial phase is performed for evaluating arterial stenoses, thrombi/emboli and occlusion, while the venous phase is for evaluating venous patency and abdominal organs which may be affected by ischemia.

It allows visualization of early signs of bowel ischemia and infarction and etiological diagnosis of disease, which is crucial for the treatment planning in acute cases. A high index of suspicion with early diagnosis with MDCT may reduce the time prior to surgery which may improve the patient's survival.

6.2 REVIEW OF LITERATURE

E. ALHAN et al. 2012, conducted a study on 107 patients with acute mesenteric ischemia over 30 years. They identified the risk factors that predict the adverse outcome of Acute Mesenteric Ischemia Hospital records and clinical data of 107 patients undergoing surgical intervention for Acute Mesenteric Ischemia during the last 30 years were reviewed and clinical outcomes as well as factors influencing mortality were analyzed. Mesenteric arterial thrombosis, arterial embolism and non occlusive mesenteric ischemia were responsible for Acute Mesenteric Ischemia in 68, 28 and 11 patients respectively. Abdominal pain was the most common presenting feature (90.6%).Peritonitis was observed in 96 patients and 24 patients were in shock. Abdominal ultrasound was performed in 46 patients, abdominal MDCT was done in 36 patients. All patients underwent surgery and 11 patients underwent second look operation .Bowel resection was done in 101 patients during the initial operation and in 7 patients during second look operation .The hospital mortality was 55.1%. MDCT was found to be a protective factor against mortality.[1]

P.H. Haghighi et al. 2008, conducted another study in which patient records of public and private hospitals with clinical diagnosis of acute abdomen were reviewed. Among the 10000 patients records studied, 105 patients were identified with Acute Mesenteric Ischemia. The mortality rate among them was 50.4%. The most common symptom in these patients was pain abdomen. The mortality rate was lower in those patients who underwent MDCT.[2]

Another study was conducted by MZ Al-Azzazy et al 2012, to evaluate the role of multi detector CT in assessment of mesenteric ischemia in clinically suspected patients. This study included 38 patients during period from October 2009 to October 2011. The patients age ranged from 38 to 72 year old (mean age was 57 ± 11.2 years). All cases met the criteria of acute (28 patients) or chronic abdominal pain (10 patients) and suspected mesenteric ischemia. All 38 cases were evaluated in surgery department, underwent CT abdomen and pelvis & CTA by using 64 multi slice GE light speed VCT. MDCT findings were correlated with surgical findings in acute mesenteric ischemia (AMI) cases. The sensitivity, specificity& accuracy of CTA in diagnosis of AMI after surgical confirmation were 96%, 66.6% & 92.8% respectively. It was concluded that MDCT is an excellent tool to find out and localize causes of AMI.[3]

P.G. Taourel et al. 1996 conducted a study to evaluate the accuracy of MDCT in the diagnosis of acute mesenteric ischemia. Reviewers blinded to patient diagnoses retrospectively compared the CT scans in a study group with those in a control group. The study group comprised 39 patients (23 men, 16 women; aged 55-88 years) with surgically proven acute mesenteric ischemia. The control group comprised of 24 patients (13 men, 11 women; aged 50-82 years) with suspected acute mesenteric ischemia that was disproved at surgery. For the diagnosis of acute mesenteric ischemia, each of the following findings had a specificity of more than 95% and a sensitivity of less than 30%: arterial or venous thrombosis, intramural gas, portal venous gas, focal lack of bowel-wall enhancement, and liver or splenic infarcts. When CT was used in

the diagnosis of suspected acute mesenteric ischemia, the detection of at least one of these signs resulted in a sensitivity of 64% (25 of 39; confidence interval, 0.49, 0.79), a specificity of 92% (22 of 24; confidence interval, 0.81, 1.00), and an accuracy of 75% (47 of 63; confidence interval, 0.64, 0.86). therefore, conclusion was made that MDCT is a valuable tool in the diagnosis of and determination of prognosis in acute mesenteric ischemia.[4]

Aouini F et al. 2012 performed a retrospective study to review the clinical data of patients hospitalized between January 2000 and December 2008 with acute mesenteric ischemia. Analysis of the factors that could influence mortality was conducted. 26 patients, predominantly male of mean age of 60 years, were included. These patients were cared for on average 4 days after the onset of symptoms. The diagnosis was made pre-operatively in 9 patients, by CT scan in 8 patients and by Doppler ultrasound in 1 patient. The cause of Acute Mesenteric Ischemia was arterial thrombosis in 19 cases, venous thrombosis in 4 cases and non occlusive mesenteric ischemia in 3 cases. 25 patients were operated on emergency 24 times by a laparotomy and one time by a laparoscopy. The surgery consisted in bowel resection in 15 patients. Revascularization of the superior mesenteric artery was associated in 4 cases. Outcome was simple in 8 patients. The mortality rate was 69%. The prognosis is better in cases of venous infarction with a mortality rate of zero. Prognosis of acute mesenteric ischemia depends on the aetiology and the quickness of treatment. It is directly linked to the extension of intestinal infarction. Hence, MDCT is an important modality for early diagnosis of acute mesenteric ischemia and thus improving the prognosis of the disease.[5]

Sung Ek et al 2000, studied the various causes of ischemic bowel disease. Various CT findings such as bowel wall thickening, intramural pneumatosis, mesenteric or portal venous gas and mesenteric arterial or venous thromboembolism, engorgement of mesenteric veins were recorded. He concluded that pathogenesis of various conditions leading to acute mesenteric ischemia helps the radiologist to diagnose acute mesenteric ischemia accurately and therefore avoids delayed diagnosis, unnecessary surgery and improves the overall prognosis.[6]

MARCO MOSCHETTA et al 2014, concluded that MDCT is a fundamental imaging modality which should be done promptly in all patients of suspected bowel ischemia and is superior to other non invasive techniques with high sensitivity, specificity, positive and negative predictive value of 64-93%, 92-100%,90-1005 and 94-98% respectively.[7]

Akira et al 2009, studied the various conditions leading to acute mesenteric ischemia and reviewed the CT appearance of Acute Mesenteric Ischemia in various conditions and concluded that CT is an important modality in the diagnosis of mesenteric ischemia.[8]

Gore RM et al 2008, studied the role of imaging in intestinal ischemic disorders and concluded that advances in MDCT contributes greatly to earlier diagnosis of intestinal ischemia ,having positive influence on outcome of the patient.[9]

Copin P et al 2018, studied that contrast-enhanced computed tomography (CT) has become the cornerstone of the diagnosis by showing features of vascular disorders (occlusion and/or insufficient blood supply) and features of

intestinal ischemic injury. CT should be performed as rapidly as possible. The goal of this review is to improve the understanding of the imaging-based diagnosis to further improve the management of this life-threatening condition.[10]

Mazzei MA et al, concluded that computed tomography angiography (CTA) has supplanted formal angiography as the diagnostic study of choice in acute mesenteric ischemia (AMI) and on the recommendation that it should be performed as soon as possible for any patient with clinical suspicion of AMI, because it could reduce the delay in diagnosing this critical condition, especially in non-occlusive forms (non-occlusive mesenteric ischemia, NOMI). CTA, in particular, allows to differentiate occlusive from non-occlusive forms and to evaluate the state of the bowel walls, dictating the appropriate treatment planning (revascularization vs non-vascular management).[11-12]

Acute intestinal ischemia is an abdominal emergency occurring when blood flow to the bowel loops decreases because of mesenteric arterial hypoperfusion, impaired venous drainage or occlusion.[13-15] It is estimated that nearly 1% of patients presenting with acute abdomen have ischemic intestinal disease involving the small bowel or colon.[15-17]

Bowel ischemia is considered a potentially transient and reversible event; however, it may lead to intestinal infarction that requires surgical or interventional management. For this reason, early diagnosis is important to improve survival rates.[18] In most cases of late or missed diagnosis, the mortality rate from intestinal infarction is very high, with a reported value ranging from 60% to 90%.[18-20] Multi-detector computed tomography (MDCT)

is a fundamental imaging technique that must be promptly performed in all patients with acute abdomen and suspected bowel ischemia. In fact, MDCT allows for correct diagnosis, contributes to appropriate treatment planning and provides important prognostic information thanks to its ability to define the nature of the disease and the extent of the anatomical damage.[21]

6.3 AIMS AND OBJECTIVES OF THE STUDY

- To assess the efficacy of Multi-Detector Computed Tomography (MDCT) Abdomen in the diagnosis of acute mesenteric ischemia.
- To correlate it with surgical and/or clinical outcome.

7. MATERIALS AND METHODS

7.1 Source of Data

This study will be conducted over a period of one and half year from 1st November 2018 to 31st May 2020 on patients with clinical suspicion of acute mesenteric ischemia referred for MDCT Abdomen to the Department of Radio-diagnosis, Dayanand Medical College & Hospital, Ludhiana.

7.2 METHOD OF COLLECTION OF DATA

This study will be conducted over a period of one and half year from 1st November 2018 to 31st May 2020 on patients with clinical suspicion of acute mesenteric ischemia referred for MDCT Abdomen to the Department of Radio-diagnosis, Dayanand Medical College & Hospital, Ludhiana. Informed consent will be obtained from all subjects /guardians before study. The clinical history regarding the onset of symptoms, clinical progression of disease and spectrum of findings will be recorded. MDCT of suspected cases will be performed on Siemens 128 slice CT scan machine after giving intravenous contrast.

Inclusion criteria

1. Imaging of acute mesenteric ischemia on Multi-Detector Computed Tomography (MDCT) Abdomen.
2. Patients with negative imaging examination and subsequently found to have features of acute mesenteric ischemia preoperatively.

Exclusion criteria

1. Patients with alternative diagnosis of acute abdomen on imaging.

2. Patients who refuse to participate in the study.

Informed consent will be obtained from all subjects /guardians before study. The clinical history regarding the onset of symptoms, clinical progression of disease and spectrum of findings will be recorded. MDCT of suspected cases will be performed on Siemens 128 slice CT scan machine after giving intravenous contrast.

OUTCOME:

This study will be conducted over the patients suspected with acute mesenteric ischemia. MDCT findings will be recorded and the efficacy of MDCT will be correlated with surgical and clinical outcome of the patient.

STATISTICAL ANALYSIS:

Data will be described in terms of range; mean ±standard deviation (± SD), median, frequencies (number of cases) and relative frequencies (percentages) as appropriate. Chi square ($\chi 2$) test will be performed and exact test was used when the expected frequency is less than 5. Sensitivity, specificity, positive and negative predictive values and accuracy of method and its confidence interval (95% CI) will be also calculated. A probability value (p value)less than 0.05 was considered statistically significant. A probability value (p value)less than 0.05 will be considered statistically significant. All statistical calculations will be done using SPSS (Statistical Package for the Social Science) SPSS 21 version statistical program for Microsoft Windows.

7.3 DOES THE STUDY REQUIRE ANY INVESTIGATIONS OR INTERVENTIONS TO BE CONDUCTED ON PATIENTS OR OTHER HUMANS OR ANIMALS? IF SO, PLEASE DESCRIBE BRIEFLY.

The study will be performed on Siemens 128 slice CT scan machine after giving intravenous contrast.

However, the study does not require any intervention to be conducted on patients

7.4 HAS ETHICAL CLEARANCE BEEN OBTAINED FROM YOUR INSTITUTION IN CASE OF 7.3?

Yes, attached herewith

8. LIST OF REFERENCES

1. Alhan E, Usta A, Çekiç A, Saglam K, Türkyılmaz S, Cinel A. A study on 107 patients with acute mesenteric ischemia over 30 years. Int J Surg. 2012;10:510-3.
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PROFORMA

S.No. MRD No.

Name Age

Address

Contact no.

Date of admission Date of discharge

Relevant history of the patient

Chief complaints

Systemic examination

Clinical diagnosis

Laboratory investigations

- hemogram
- LFTs
- RFTs
- Serum LDH Level
- Prothrombin time / INR
- APTT
- Cardiac evaluation (ECHO/ECG)

Signature of Candidate **Signature of Supervisor**

CT findings

- Bowel wall thickening / thinning
- Attenuation of bowel wall on non-contrast phase
- Enhancement of bowel wall on post – contrast scan
- Bowel dilatation
- Changes in the mesentery
- Pneumatosis intestinalis
- Patency of mesenteric vessels
- Abdominal fluid collection
- Free fluid in peritoneal cavity
- Involvement of other organs like liver, spleen and pancreas
- Portomesenteric pneumatosis
- Pneumoperitoneum and retropneumoperitoneum

CT Diagnosis-

Intraoperative findings-

Report of histopathology-

Signature of Candidate **Signature of Supervisor**

INFORMED PATIENT CONSENT

Date: _____

I.....D/o, W/o, S/o..... .....am willing to participate in the study **"ROLE OF MDCT IN PATIENTS OF ACUTE MESENTERIC ISCHEMIA AND CORRELATION WITH CLINICO-SURGICAL OUTCOME"** The procedure with its complications has been explained to me in local vernacular language. I have fully understood that no special tests and extra expenditure in any form, merely for the purpose of thesis is being carried out. I am free to opt out the study any time without assigning any reason.

....

Signature of the Witness Signature of the patient

Name:

Signature of Candidate **Signature of Supervisor**

मरीज अनुमति फार्म

तिथि _____

मैं _____ पत्नी/पुत्र/पुत्री _____

निवासी _____

इस शोधकार्य **"ROLE OF MDCT IN PATIENTS OF ACUTE MESENTERIC ISCHEMIA AND CORRELATION WITH CLINICO-SURGICAL OUTCOME"** में भाग लेने के लिए सहमत हूँ। मैं इस शोधकार्य में भाग लेने के लिए अपनी स्वेच्छा से तैयार हूँ। मैं पुष्टि करता/करती हूँ की यह स्वीकृति देने के लिए मुझे कोई आर्थिक प्रलोभन नहीं दिया गया और न ही दबाव डाला गया है। मुझे इस शोधकार्य का उद्देश्य स्पष्ट कर दिया गया है और मुझे यह विश्वास है की यह विज्ञान और मानवता के लाभ के लिए है। मुझे इस शोधकार्य में होने वाले जोखिम के बारे में समझा दिया गया है और मेरी समझ में यह जोखिम बहुत मामुली है।

मैं इस शोधकार्य में भाग लेने के सम्बन्ध में किसी भी समय अपनी अस्वीकृति व्यक्त कर सकता/सकती हूँ और मेरे अस्वीकृति व्यक्त करने का मेरे इलाज पर कोई प्रभाव नहीं पड़ेगा।

_____

गवाह के हस्ताक्षर

नाम:

_____

रोगी के हस्ताक्षर/अंगूठे का निशान

नाम:

_____

अन्वेषक के हस्ताक्षर

_____

विद्यार्थी के हस्ताक्षर

ਮਰੀਜ਼ ਰਜ਼ਾਮੰਦੀ ਫਾਰਮ

ਮਿਤੀ_____

ਮੈ_____ਪਤਨੀ/ਪੁੱਤਰ/ਪੁੱਤਰੀ_____

ਵਾਸੀ _____

"ROLE OF MDCT IN PATIENTS OF ACUTE MESENTERIC ISCHEMIA AND CORRELATION WITH CLINICO-SURGICAL OUTCOME" ਤੇ ਚਲ ਰਹੀ ਖੋਜ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਰਜ਼ਾਮੰਦ ਹਾਂ। ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਮੈ ਆਪਣੀ ਮਰਜ਼ੀ ਨਾਲ ਤਿਆਰ ਹਾਂ। ਮੈ ਇਹ ਦਸਣਾ ਚਾਹੁੰਦਾ ਹਾਂ/ ਚਾਹੁੰਦੀ ਹਾਂ ਕੇ ਇਹ ਰਜ਼ਾਮੰਦੀ ਦੇਣ ਵਾਸਤੇ ਮੈਨੂ ਕਿਸੇ ਵੀ ਤਰਾਂ ਦਾ ਲੋਭ-ਲਾਲਚ ਨਹੀ ਦਿੱਤਾ ਗਿਆ ਅਤੇ ਨਾ ਹੀ ਕੋਈ ਦਬਾ ਪਾਇਆ ਗਿਆ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਦਾ ਮਨੋਰਥ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਭਰੋਸਾ ਦਵਾਇਆ ਗਿਆ ਹੈ ਕੇ ਇਹ ਖੋਜ ਵਿਗਿਆਨ ਅਤੇ ਮਾਨਵਤਾ ਦੀ ਭਲਾਈ ਲਈ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਵਿਚ ਹੋਣ ਵਾਲੇ ਖਤਰੇ ਬਾਰੇ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਯਕੀਨ ਹੈ ਕੇ ਇਹ ਖਤਰਾ ਬਹੁਤ ਮਾਮੂਲੀ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਦਾ ਢੰਗ – ਤਰੀਕਾ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ।

ਮੈ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਬਾਰੇ ਆਪਣੀ ਰਜ਼ਾਮੰਦੀ ਕਿਸੇ ਵੀ ਸਮੇ ਵਾਪਸ ਲੈ ਸਕਦਾ ਹਾਂ/ ਸਕਦੀ ਹਾਂ ਅਤੇ ਮੇਰੀ ਰਜ਼ਾਮੰਦੀ ਵਾਪਸ ਲੈਣ ਦਾ ਮੇਰੇ ਇਲਾਜ ਤੇ ਕੋਈ ਅਸਰ ਨਹੀ ਹੋਵੇਗਾ।

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ਗਵਾਹ ਦੇ ਹਸਤਾਖਰ

ਮਿਤੀ_____

ਪਤਾ _____

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ਮਰੀਜ਼ ਦੇ ਹਸਤਾਖਰ

ਮਿਤੀ_____

ਪਤਾ _____

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ਨਿਰੀਖਕ ਦੇ ਹਸਤਾਖਰ

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ਸਿਖਿਆਰਥੀ ਦੇ ਹਸਤਾਖਰ